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TIME SERIES ANALYSIS OF GUNNER TRACKING ERROR

Nancy R. Rich, et al

Army Missile Command
Redstone Arsenal, Alabama

3 October 1973

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U.S. ARMY MISSILE COMMAND
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13. ABSTRACT

This report includes the time series analysis of gunner error data and the formulation of a simulation model to be used in future applications.

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CONTENTS

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1. Introduction

Successful prediction of the amount of error incurred in gunner tracking of a moving target has become an important phase in the development of weapon systems. A great deal of data in engineering, economics, and the natural sciences occurs in the form of time series where observations are dependent and where the nature of this dependence is of utmost importance.

The purpose of this report is to present an evaluation of the gunner error data described in Section 2, thereby defining a time series model. This model and its parameters can be used to simulate data for future problems of a similar nature or may be used as a subroutine to missile flight simulation.

2. Data Description

Tests to determine the gunner tracking error characteristics were conducted at Redstone Arsenal during the period 13 through 18 July 1972. The King Air, a twin engine Beechcraft, was the target utilized for these tests.

A 16mm film camera was attached to the monocular output of the tracker unit. This output presents the same view to the film camera as the binocular output presents to the gunner.

There were four gunners who participated in the tests. They were instructed to track the centroid to the target aircraft when details were not resolvable. When resolvable they were to track the intersection at the wing and fuselage. The amount of error was shown to be independent of individual gunner, that is, there was no statistical significance.

3. Model Building

This section discusses the time series model building for the gunners' error data. After examining all the data available, we conclude that the data forms a stationary time series except at the beginning where a transient occurs during acquisition, and at the end where a transient is introduced by the simulated missile in flight signal. Runs with too few data were eliminated. The total number of runs was then 143. A few nonstationary data can also be seen. They occupy 13.29 percent of the total.

When the data are recorded with equally spaced time intervals, we generally use a linear time series model to fit the data. A commonly used model for univariate time series can be written as

$$Y_t - \mu = \phi_1(Y_{t-1} - \mu) + \phi_2(Y_{t-2} - \mu) + \ldots + \phi_p(Y_{t-p} - \mu)$$

$$+ a_t - \theta_1 a_{t-1} - \ldots - \theta_q a_{t-q} \tag{1.1}$$

where

subscript t = time

Y_t = the value of the time series at time t

μ = the expected value of Y_t

a_t = a white noise process, i.e., a_t is independent, identically distributed $N(0, \sigma_a^2)$

p, q = two parameters depending on the properties of a particular time series.

Model (1.1) is called a mixed model with autoregressive and moving average components. It has been widely used in practice with fruitful results (see e.g., Box and Jenkins [1], Fuller and Tsokos [2], Cleveland [3, 4], and Box et. al [5]). The intuitive idea behind the model (1.1) is the assumption that the present value Y_t depends on the values of Y_t in the near past, i.e., $Y_{t-1}, Y_{t-2}, \ldots, Y_{t-p}$. This is the autoregressive component

$$(Y_t - \mu) = \phi_1(Y_{t-1} - \mu) + \phi_2(Y_{t-2} - \mu) + \ldots + \phi_p(Y_{t-p} - \mu) \quad .$$

The moving average component $a_t - \theta_1 a_{t-1} - \ldots - \theta_q a_{t-q}$ indicates that the present value Y_t depends not only on the present noise a_t, but also the previous noise $a_{t-1}, \ldots, a_{t-q}$. This is reasonable since the noise will not diminish very rapidly in real situations. The noise prolongs its influence on Y_t for a certain period.

In practice when time series data are given, a model of the form (1.1) can generally be built. The detailed procedure has been given in Box and Jenkins [1]. There are four main steps.

a. Model Identification

In this first step, autocorrelation coefficients, partial autocorrelation coefficients, and inverse correlation coefficients (e.g., Cleveland [3]) are used to determine the values of p and q in

model (1.1). The value p is called the order of the autoregressive component and the value q is called the order of the moving average component in a mixed model (1.1).

b. Parameter Estimation

After the values of p and q have been determined, there are p + q + 2 parameters: μ, ϕ_1, ϕ_2 ..., ϕ_p, θ_1, ..., θ_q and the variance σ_a^2 of a_t to be determined. The method used to estimate ϕ's and θ's has been described in Box and Jenkins (Chapter 7, [1]), Clevenson [6], and Parzen [7]. The main technique is the maximum likelihood estimation. Generally, the calculation needs the help of spectral density estimation [7] or nonlinear least squares estimation [1].

c. Diagnostic Checking

The estimated values $\hat{\mu}$, $\hat{\underset{\sim}{\phi}}$, $\hat{\underset{\sim}{\theta}}$, and $\hat{\sigma}_a^2$ of the parameters μ, $\underset{\sim}{\phi}$, $\underset{\sim}{\theta}$, and σ_a^2, respectively, are not generally equal to the real value of these parameters. The model with estimated parameters

$$(Y_t - \hat{\mu}) = \hat{\phi}_1(Y_{t-1} - \hat{\mu}) + \ldots + \hat{\phi}_p(Y_{t-p} - \hat{\mu}) + a_t - \hat{\theta}_1 a_{t-1} - \ldots - \hat{\theta}_q a_{t-q} \qquad (1.2)$$

may not fit the original data well. Diagnostic checking determines whether our estimated model fits the data well. The residual process $[\hat{a}_t]$ is examined. If the $[\hat{a}_t]$ is close to a white noise process, the model is considered to be adequate and the whole model building procedure is over. Otherwise, we go to the next step.

d. Modification of the Model

If the model we built is found inadequate through the diagnostic checking, we will try to fit the data by a new modified model. Generally, the residual process $[\hat{a}_t]$ will reveal some information on how the model should be rebuilt. In most cases, a pair of new values of p and q will be obtained. Using these new values of p and q, we undergo steps b., c., and d. for this new model building.

All the four steps have been carefully followed for building the gunners' error data model. For the (apparently) stationary time series, with azimuth and elevation both counted, the total number of realizations

was 248. Each time series of azimuth and elevation is run separately (Tables 1 and 2). Sixty-two percent of the stationary series can be fitted well by a third order autoregressive process [$p = 3$, $q = 0$ in model (1.1)], i.e.,

$$Y_t - \mu = \phi_1(Y_{t-1} - \mu) + \phi_2(Y_{t-2} - \mu) + \phi_3(Y_{t-3} - \mu) + a_t \quad . \tag{1.3}$$

A few data can not be fitted well by (1.3); they are fitted by a more complicated model. These models and their percentages of the total data are given in Table 1. Due to the biological and psychological differences among gunners, there are variations in these parameters. The means and variances of these parameters are also given in Table 1.

TABLE 1. GUNNER'S ERROR MODEL FOR AZIMUTH

General model (3rd order autoregressive process) (62.90%)					
	μ	ϕ_1	ϕ_2	ϕ_3	σ_a^2
Mean	0.0393	0.4489	0.2362	0.1245	0.0128
Variance	0.0108	0.0170	0.0066	0.0087	0.0001
Special Model					
			Mean		Variance
1) $\phi_4 \neq 0$		(17.74%)	0.1490		0.0050
2) $\phi_5 \neq 0$		(4.84%)	0.0962		0.0076
3) $\phi_6 \neq 0$		(5.65%)	0.0485		0.0189
4) $\phi_7 \neq 0$		(3.22%)	0.1218		0.0060
5) $\phi_8 \neq 0$		(0.81%)	0.1844		0.0000
6) $\phi_9 \neq 0$		(2.42%)	0.0196		0.0142
7) $\phi_{10} \neq 0$		(1.61%)	0.0568		0.0145
8) $\phi_{11} \neq 0$		(0.81%)	0.0970		0

TABLE 2. GUNNER'S ERROR MODEL FOR ELEVATION

General model (3rd order autoregressive process) (60.48%)

	μ	ϕ_1	ϕ_2	ϕ_3	σ_a^2
Mean	-0.0515	0.3692	0.2165	0.1448	0.0045
Variance	0.0124	0.0188	0.0051	0.0057	0.0001

Special Model

		Mean	Variance
1) $\phi_4 \neq 0$	(15.32%)	0.1535	0.0014
2) $\phi_5 \neq 0$	(8.87%)	0.1255	0.0088
3) $\phi_6 \neq 0$	(7.25%)	0.1125	0.0039
4) $\phi_7 \neq 0$	(4.84%)	0.1221	0.0087
5) $\phi_8 \neq 0$	(0.81%)	0.1497	0
6) $\phi_9 \neq 0$	(0.81%)	0.1294	0
7) $\phi_{10} \neq 0$	(0.81%)	0.1178	0
8) $\phi_{11} \neq 0$	(0.81%)	0.0573	0

A question arises whether the azimuth error and elevation error are dependent on each other during a gunner's aiming. The data show that we can consider the azimuth error and elevation error to be two independent processes. The following procedure is followed.

A general model describing the relation between two time series is a linear transfer function model. Let X_t be the time series of azimuth and Y_t be the time series of elevation. A linear transfer function model can be written as

$$(Y_t - \mu_y) = \alpha_1(Y_{t-1} - \mu_y) + \dots + \alpha_m(Y_{t-m} - \mu_y)$$
$$+ \beta_1(X_{t-1} - \mu_x) + \dots + \beta_n(X_{t-n} - \mu_x) + N_t \tag{1.4}$$

where

$\mu_y = E(Y_t)$

$\mu_x = E(X_t)$

N_t = a noise process

m, n = the numbers of past values of X_t and Y_t on which the present Y_t depends.

Intutitively, model (1.4) indicates that the present azimuth value Y_t may depend on the previous values of both azimuth and elevation. This model has been used in many practical situations and gives good results (see e.g., Box and Jenkins [1]). Since we have already found a good model for Y_t in the previous model buildings, we may combine the Y model and (1.4) and have

$$a_t = \beta_1(X_{t-1} - \mu_x) + \ldots + \beta_n(X_{t-n} - \mu_x) + N_t \qquad (1.5)$$

where a_t is the noise process from the model of Y_t. Since a_t is a white noise process, the values β's can be easily estimated (Box and Jenkins [1] p. 380).

An attempt has been made to fit all the corresponding pairs of azimuth error data and elevation error data by model (1.4). Except for a few exceptions (1 percent of the total), the β values are very small (less than 0.05 for all β_1, β_2, ..., β_{25}). Hence, we consider that the error in elevation has no significant influence on that in azimuth. A similar model fitting by replacing X by Y and Y by X in (1.4) has also been run for all pairs of data. An independence relation is also obtained here. Hence, we conclude that there is no significant dependence between azimuth error and elevation error.

4. Simulation Procedure

In order to simulate the total performance of a guided missile system with a man in the loop, we may use the gunner's model described in the previous section. Considering the nonrepeatability of man's reactions, it must be realized that for any single simulation the error model will not give the same results as given by man. However, man's behavior on the average should agree with that of the error mode.

Simulation of a gunner's behavior may be performed as follows:

a) Choose 2 random numbers γ_1 and γ_2 in [0, 1]. γ_1 is used to construct azimuth error, if

$\gamma_1 \in$ [0, 0.6290], a third order autoregressive model will be used,

$\gamma_1 \in$ [0.6291, 0.8064], a fourth order autoregressive model with $\phi_4 \neq 0$ will be used,

$\gamma_1 \in$ [0.8065, 0.8548], a fifth order autoregressive model with $\phi_5 \neq 0$ will be used,

$\gamma_1 \in$ [0.8549, 0.9113], a sixth order autoregressive model with $\phi_6 \neq 0$ will be used,

$\gamma_1 \in$ [0.9114, 0.9435], a seventh order autoregressive model with $\phi_7 \neq 0$ will be used,

$\gamma_1 \in$ [0.9436, 0.9516], an eighth order autoregressive model with $\phi_8 \neq 0$ will be used,

$\gamma_1 \in$ [0.9517, 0.9758], a ninth order autoregressive model with $\phi_9 \neq$ will be used,

$\gamma_1 \in$ [0.9759, 0.9919], a tenth order autoregressive model with $\phi_{10} \neq 0$ will be used,

$\gamma_1 \in$ [0.9920, 1.00], an eleventh order autoregressive model with $\phi_{11} \neq 0$ will be used.

Thus, we have chosen a model for azimuth error process. γ_2 is used to construct elevation error, if

$\gamma_2 \in$ [0, 0.6048], a third order autoregressive model will be used,

$\gamma_2 \in$ [0.6049, 0.7580], a fourth order autoregressive model with $\phi_4 \neq 0$ will be used,

$\gamma_2 \in$ [0.7581, 0.8467], a fifth order autoregressive model with $\phi_5 \neq 0$ will be used,

$\gamma_2 \in$ [0.8468, 0.9192], a sixth order autoregressive model with $\phi_6 \neq 0$ will be used,

$\gamma_2 \in$ [0.9193, 0.9676], a seventh order autoregressive model with $\phi_7 \neq 0$ will be used,

$\gamma_2 \in [0.9677, 0.9757]$, an eighth order autoregressive model with $\phi_8 \neq 0$ will be used,

$\gamma_2 \in [0.9758, 0.9838]$, a ninth order autoregressive model with $\phi_9 \neq 0$ will be used,

$\gamma_2 \in [0.9839, 0.9919]$, a tenth order autoregressive model with $\phi_{10} \neq 0$ will be used,

$\gamma_2 \in [0.9920, 1.0]$, an eleventh order autoregressive model with $\phi_{11} \neq 0$ will be used.

b) Use normal random number generator to generate the required parameters μ, ϕ's, and σ_a^2.

c) Using a polynomial root solver, check the roots of $X^p - \phi_1 X^{p-1} \ldots\ldots - \phi_p = 0$. If any of the roots is greater than or equal to 1, discard this set of ϕ's and select another group of parameters.

d) Let X_t denote the azimuth error process and Y_t denote the elevation error process. Then according to the models and parameters chosen by steps a) and b), we can simulate X_t and Y_t consecutively by generating normal random derivates a_t from $N(0, \sigma_a^2)$.

e) If the perfect aim of a gunner at time t is (A_t, E_t), then our simulated coordinate of a gunner at time t is $(A_t + X_t, E_t + Y_t)$.
A simulation example:

INITIALLY SELECTED VALUES

	MEAN	AVAR	PHI1	PHI2	PHI3	JUMP	PHI(JUMP)
AZIMUTH	.2203	.0113	.6205	-.0512	.2365		
ELEVATION	.3351	.0127	.5279	.2498	.1332		

TIME	AZIMUTH	ELEVATION	TIME	AZIMUTH	ELEVATION	TIME	AZIMUTH	ELEVATION	TIME	AZIMUTH	ELEVATION
1	-.1755	-.1324	56	-.1713	.0100	111	-.0413	.0948	166	.2437	.2640
2	.1337	.3260	57	-.2563	.1111	112	-.0274	-.0495	167	.1933	.3051
3	.2303	-.1939	58	-.1459	-.0346	113	.1250	.0530	168	.2600	.1620
4	.1593	-.1348	59	-.3663	-.6635	114	.1638	.0499	169	.0833	.0606
5	-.3555	.1096	60	-.3365	-.1450	115	.0052	.0014	170	.1182	.1169
6	.3833	-.1320	61	-.1431	-.2761	116	-.0419	-.1819	171	.3096	.0482
7	.3245	.1592	62	-.2125	-.1550	117	.0903	.0056	172	.1514	.1774
8	.2111	.1777	63	-.3637	-.1914	118	.1623	.1494	173	.2749	.3419
9	.1289	-.1413	64	-.4152	-.3334	119	.1935	.2334	174	.3294	.3336
10	.1762	.2436	65	-.2594	-.3565	120	.1262	.1920	175	.4046	.2718
11	.1515	.2966	66	-.3902	-.4550	121	.1951	.2537	176	.2966	.3794
12	.1184	.3773	67	-.4961	-.4175	122	.1772	.1748	177	.1921	.2919
13	.2957	.2703	68	-.4593	-.4215	123	.3500	.0961	178	.2636	.3193
14	-.1275	.3781	69	-.3340	-.4551	124	.1603	.0688	179	.2633	.0622
15	-.1167	-.1395	70	-.2110	-.3093	125	.3709	.1091	180	.1621	.2626
16	-.2593	.2017	71	-.3547	-.3630	126	.2778	.1235	181	.2450	.0831
17	-.3155	.1537	72	-.3612	-.4910	127	.3059	-.0464	182	.1449	.2044
18	-.2328	-.3970	73	-.4432	-.4258	128	.4577	.1629	183	.1952	.2311
19	.3211	.1299	74	-.3706	-.4183	129	.3601	.1470	184	.1603	.1304
20	-.1443	.1584	75	-.3651	-.4277	130	.1373	.3204	185	.1399	.3868
21	-.1172	.0569	76	-.2047	-.3537	131	.4368	.1506	186	.1469	.4428
22	-.3036	.1733	77	-.2401	-.3624	132	.3475	.1128	187	.1625	.3353
23	-.3147	.1334	78	-.3569	-.4524	133	.3962	.2670	188	.5581	.4863
24	-.2152	.2472	79	-.1977	-.3342	134	.5773	.1383	189	.0738	.4723
25	-.2304	.3407	80	-.1686	-.2520	135	.4983	.3554	190	-.0179	.5723
26	-.3435	.4307	81	-.4736	-.3976	136	.3932	.0652	191	.0657	.4590
27	-.1038	.2745	82	-.4503	-.1160	137	.4714	.2137	192	.0321	.5774
28	-.2372	.2361	83	-.4261	-.0845	138	.2162	.1507	193	-.0298	.5470
29	-.2521	.4894	84	-.4642	.0444	139	.3195	.1014	194	.1346	.3726
30	-.3109	.5089	85	-.5049	.0932	140	.2959	.2949	195	.1263	.2937
31	-.2041	.4745	86	-.5195	.1963	141	.1976	.1052	196	.0996	.4242
32	-.1236	.4926	87	-.7633	.1236	142	.1618	.2110	197	.3020	.3215
33	-.2345	.5559	88	-.4621	.0546	143	.0587	.1769	198	.2477	.2918
34	-.4167	.7275	89	-.3524	.1470	144	.1413	.3857	199	.3308	.3443
35	-.3195	.5641	90	-.4652	.0010	145	.1026	.3874	200	.3321	.5021
36	-.3339	.5136	91	-.4355	-.3137	146	.1243	.3499	201	.3319	.1302
37	-.2531	.5282	92	-.5413	-.0205	147	.0290	.2502	202	.1616	.1609
38	-.1533	.3371	93	-.3061	.0049	148	.0516	.3292	203	.0175	-.0214
39	-.1524	.5560	94	-.4743	.0191	149	.0754	.1005	204	.1515	-.1406
40	-.1716	.2312	95	-.2938	-.0635	150	.0527	.1359	205	.2408	.0977
41	-.1542	.2583	96	-.2093	-.0746	151	.0711	.0936	206	.2399	.0597
42	-.1743	.1566	97	-.3274	-.0952	152	.1511	.0583	207	.5116	.0469
43	-.0974	.1561	98	-.1225	.0103	153	.1491	.1552	208	.3942	.1561
44	-.1385	.2254	99	.0135	-.0138	154	.1672	.1010	209	.4456	-.0706
45	-.0430	.3322	100	-.0056	.0696	155	.2442	.0372	210	.5296	.0256
46	-.0029	.3797	101	-.2883	.0235	156	.2035	.1405	211	.5029	.1296
47	-.1358	.1160	102	-.1614	-.1036	157	.5365	.0449	212	.5209	.1026
48	-.1348	.2423	103	-.0672	.0838	158	.3346	.0997	213	.5748	.1072
49	-.1948	.2354	104	-.1763	.0243	159	.3233	.0388	214	.5579	.0028
50	-.2350	.1844	105	.0667	.2253	160	.4454	.0233	215	.4930	.0199
51	-.1318	.2905	106	-.0737	.0626	161	.4796	.0215	216	.4704	.0953
52	-.1265	.2555	107	.0561	.0685	162	.3816	.1459	217	.6232	-.2472
53	-.1507	.3026	108	.1718	-.0691	163	.5515	.1028	218	.4398	.1398
54	-.1684	.2459	109	.1719	.1873	164	.3485	.2477	219	.6565	.0273
55	-.2960	.2504	110	-.0166	.1193	165	.1613	.1408	220	.7171	.0855

5. Data Listing

ID	C	GO	END	N	SA2	MEAN	PHI(1)	PHI(2)	PHI(3)	PHI(4)	J	PHI(J)
71	A	200	1871	1672	.0113	.0144	.4264	.2255	.0597	.1950		
71	F	200	1871	1672	.0137	-.0635	.3749	.1885	.1763			
72	A	200	1846	1647	.0140	.0609	.3738	.2084	.1884	.1840		
72	F	200	1846	1647	.0112	-.0425	.3455	.2978	.1993			
73	A	200	1900	1701	.0060	.4496	.5839	.2665	.1235			
73	F	200	1900	1701	.0155	.0033	.2696	.3010	.1691	.1792		
74	A	200	1840	1641	.0078	.3525	.4525	.3704	.1419			
74	F	200	1840	1641	.0126	-.0575	.3259	.2309	.1909			
75	A	200	1969	1770	.0148	.1717	.4411	.2000	.0206	.3001		
75	F	200	1969	1770	.0064	.0034	.3297	.2425	.1903	.1618		
76	A	100	700	601	.0159	.2694	.6598	.2501	.0576			
76	F	100	700	601	.0086	-.0303	.3532	.2436	.1018		6	.1093
77	A	1	1000	1000	.0095	.0770	.4021	.1799	.2710			
77	F	1	1000	1000	.0080	-.1069	.1017	.1749	.1405	.1283		
79		NONSTATIONARY ERRORS										
80	A	1	800	800	.0058	.0256	.3702	.1945	.1168			
80	F	1	800	800	.0030	[illegible]	.2284	.1367	.1403	.1397		
82		NONSTATIONARY ERRORS										
83	A	50	600	551	.0170	-.0 10	.4394	.1611	.0806	.1514		
83	F	50	600	551	.0382	-.1897	.4015	.2132	.0896			
84	A	300	700	401	.0221	.3117	.5664	.1914	.0938			
84	F	300	700	401	.0201	.0730	.5187	.2114	.0518			
85	A	1	600	600	.0119	.0418	.2852	.2704	.2035		7	.1578
86	F	1	600	600	.0255	-.1488	.2901	.2907	.2063			
87	A	100	969	870	.0207	.1607	.5782	.3003	.0406			
87	F	100	969	870	.0461	-.2600	.2633	.2518	.2301			
88	A	100	650	551	.0104	.0275	.5184	.1914	.1963			
89	F	100	650	551	.0222	-.1410	.3069	.1198	.1529			
90	A	160	420	261	.0072	.0641	.5248	.2078	.1911		7	.0072
90	F	160	420	261	.0052	-.1017	.4602	.0709	.2247		5	.0685
91	A	50	619	570	.0383	-.0144	.5027	.3148	.0588			
91	F	50	619	570	.0361	-.1740	.3097	.2126	.1909			
92		NONSTATIONARY ERRORS										
93	A	50	635	586	.0036	.0498	.6677	.3037	-.0788			
93	F	50	635	586	.0104	-.0817	.2702	.2114	.1912			
94	A	100	462	363	.0164	-.0925	.3303	.1609	.1134		5	.1606
94	F	100	462	363	.0092	-.0466	.3146	-.0297	.2530			
95	A	100	400	301	.0043	.0473	.4300	.3193	.1472			
95	F	100	400	301	.0224	-.1197	.0611	.1491	.1369		6	.1471
96	A	50	478	429	.0035	.0710	.7877	.1634	-.0884			
96	F	50	478	429	.0090	-.0271	.5178	.2314	.0756			
98	A	100	691	592	.0073	-.0097	.6595	.1474	.0879			
98	F	100	691	592	.0169	.0890	.3740	.1887	.1934	.1409		
99	A	90	446	367	.0134	-.0958	.2680	.1778	.3652			
99	F	80	446	367	.0055	-.0370	.3508	.2133	.2557			
100	A	40	380	341	.0025	.0161	.7123	.1649	.0142			
100	F	40	380	341	.0130	-.0327	.2340	.3581	.1691			
101	A	50	280	231	.0202	-.1301	.2144	.3572	.2279			
101	F	50	280	231	.0040	.0462	.6545	.2046	-.0224			
102	A	50	500	451	.0244	-.0771	.4119	.1364	-.0135	.2149		
102	F	50	533	451	.0074	.0138	.5838	.0365	.2737			
104	A	100	557	458	.0063	.0048	.4172	.3274	.0790			
104	F	100	557	458	.0241	-.1957	.1087	.1763	.0714	.1667		
105	A	100	1000	901	.0064	-.0411	.4528	.3484	.0649			
105	F	100	1000	901	.0067	.0000	.4530	.3541	.0322			

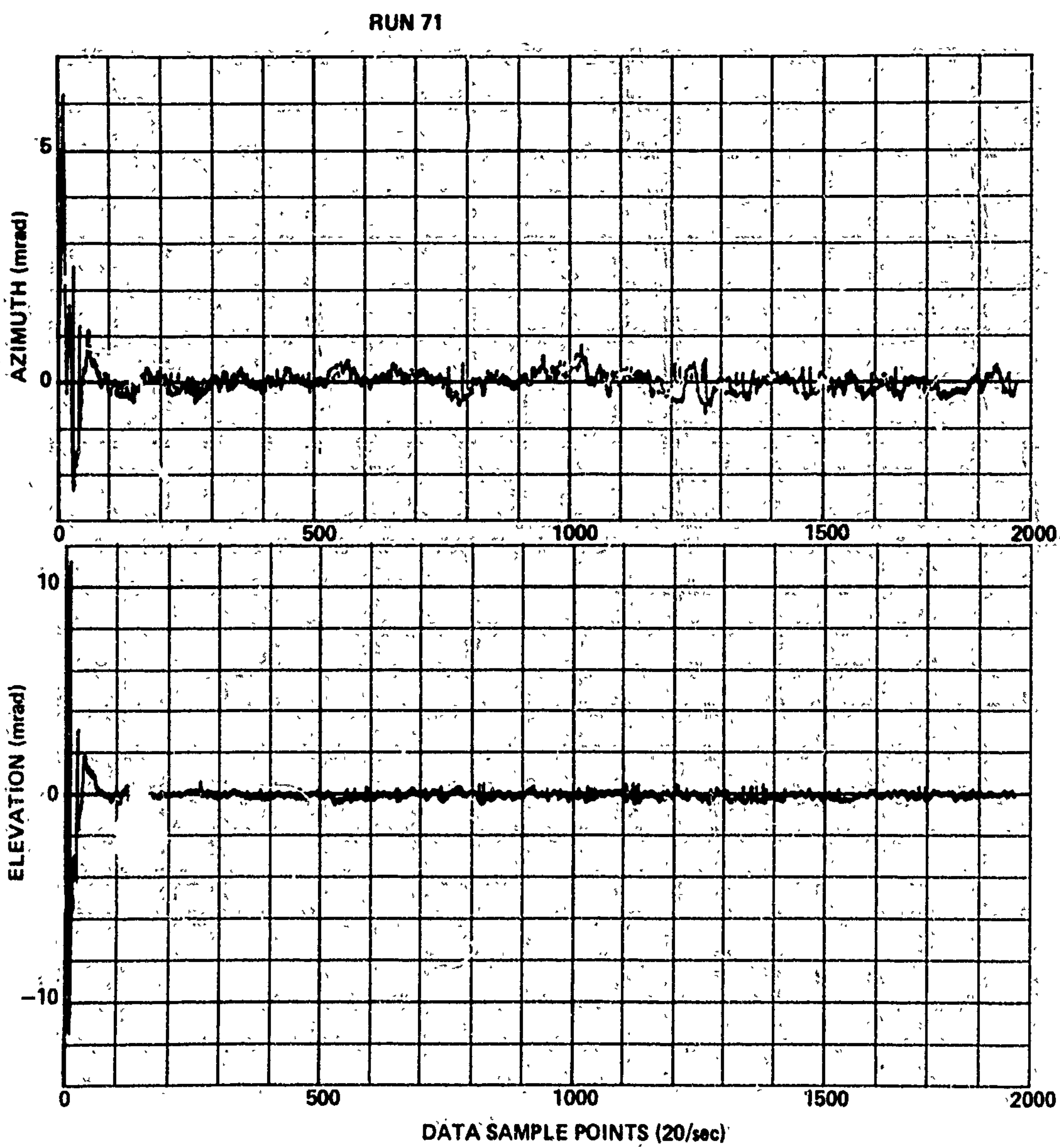
106	A	100	500	401	.0050	-.0160	.3821	.2955	.1596		5	.0604
106	F	100	500	401	.0352	-.2446	.0917	.2914	.1532		6	.1982
107	A	100	639	540	.0250	-.1320	.3561	.1739	.2001			
107	F	100	639	540	.0216	-.0874	.3435	.2668	.1681		6	.0882
108	A	50	547	498	.0023	.0715	.4978	.3109	.1839		9	-.1140
108	F	50	547	498	.0254	-.2015	.2893	.1421	.2106			
109		NONSTATIONARY ERRORS										
110	A	100	400	301	.0121	.0040	.3860	.1864	.2853			
110	F	100	400	301	.0148	-.1021	.1354	.1328	.0164		5	.2499
111	A	100	1390	1291	.0350	-.0277	.2706	.1624	.1802	.1679	5	.1407
111	F	100	1390	1291	.0274	-.1155	.1800	.2694	.2173			
112	A	100	1500	1401	.0117	-.0216	.3628	.2952	.0593	.1779		
112	F	100	1500	1401	.0142	-.0667	.2767	.1841	.0926	.1803		
113	A	100	1865	1766	.0059	.1911	.4192	.2913	.2476			
113	F	100	1865	1766	.0158	-.0590	.2720	.2171	.2246		7	.1522
114		NO STATIONARY ERRORS										
115	A	100	1801	1702	.0069	.0693	.4333	.2719	.2077			
115	F	100	1801	1702	.0176	-.1512	.2379	.1540	.1671		5	.1657
118	A	200	1400	1201	.0217	-.0544	.4501	.1877	.0839		6	.1722
118	F	200	1400	1201	.0136	-.1277	.4769	.2734	.1630			
119		NONSTATIONARY ERRORS										
120	A	100	1842	1743	.0693	-.1709	.2288	.2019	.2573	.2196		
120	F	100	1842	1743	.0067	-.0300	.4493	.3072	.1326			
121	A	200	1895	1696	.0214	-.0311	.5367	.2134	.1149			
121	F	200	1895	1696	.0131	-.0900	.3927	.2076	.0991			
122	A	100	1900	1801	.0369	-.1522	.4019	.2378	.1770			
122	F	100	1900	1801	.0094	-.0312	.4926	.1990	.1299			
123	A	200	1887	1688	.0219	-.0336	.3915	.2248	.1775	.1351		
123	F	200	1887	1688	.0132	-.0708	.3962	.2564	.2039			
124	A	200	1600	1401	.0245	-.1123	.4691	.1291	.1349		10	.1772
124	F	200	1600	1401	.0132	-.0114	.4846	.3025	.0705			
126	A	1	1300	1300	.0025	.1239	.6558	.2671	.0349			
126	F	1	1300	1300	.0169	-.1089	.2814	.3412	.1815			
127	A	1000	1800	801	.0421	-.1025	.2014	.2487	.2786	.1782		
127	F	1000	1800	801	.0195	-.1590	.3954	.2123	.1482	.0598		
128	A	1000	1582	583	.0092	.0356	.5331	.2694	.0936			
128	F	1000	1582	583	.0129	-.0579	.4365	.2194	.1609			
129	A	200	1400	1201	.0519	-.2150	.3659	.2150	.2142			
129	F	200	1400	1201	.0106	-.0479	.3628	.2668	.1580			
130	A	200	1794	1595	.0106	.1361	.4586	.2716	.2202			
130	F	200	1794	1595	.0064	.0160	.4880	.2494	.1796			
132	A	200	1400	1201	.0213	-.0930	.3973	.3047	.1221			
132	F	200	1400	1201	.0134	-.0602	.5328	.1996	.1414			
133	A	200	1785	1586	.0271	-.1965	.3816	.2473	.1585		11	.0970
133	F	200	1785	1586	.0167	-.0701	.3527	.3065	.1737			
134		TOO FEW DATA										
135		TOO FEW DATA										
136	A	700	1000	301	.0170	-.0444	.4163	.2690	.1633			
136	F	700	1000	301	.0068	.0061	.7834	.1805	-.1006			
138	A	1	600	600	.0067	.0068	.2308	.3758	.1924	.1039		
138	F	1	600	600	.0075	-.0514	.3373	.3601	.1412			
139	A	1	600	600	.0012	.0558	.6436	.2495	.0025			
139	F	1	600	600	.0037	-.0429	.3054	.2288	.1893		8	.1497
140		NONSTATIONARY ERRORS										
141	A	50	450	401	.0064	-.0227	.5580	.2370	.0972			
141	F	50	450	401	.0070	-.0455	.5764	.2072	.1062			
142	A	50	600	551	.0038	-.0236	.4963	.2384	.0857			
142	F	50	600	551	.0061	-.0515	.4462	.2150	.1861			
144	A	20	700	681	.0076	.0261	.4710	.2212	.1200			
144	F	20	700	681	.0080	.0079	.4278	.2462	.2341			
145	A	50	500	451	.0036	.0239	.5016	.3745	-.0037			
145	F	50	500	451	.0064	.0015	.6275	.2415	.0011			
147	A	80	400	321	.0080	.0525	.3444	.0274	.0109			

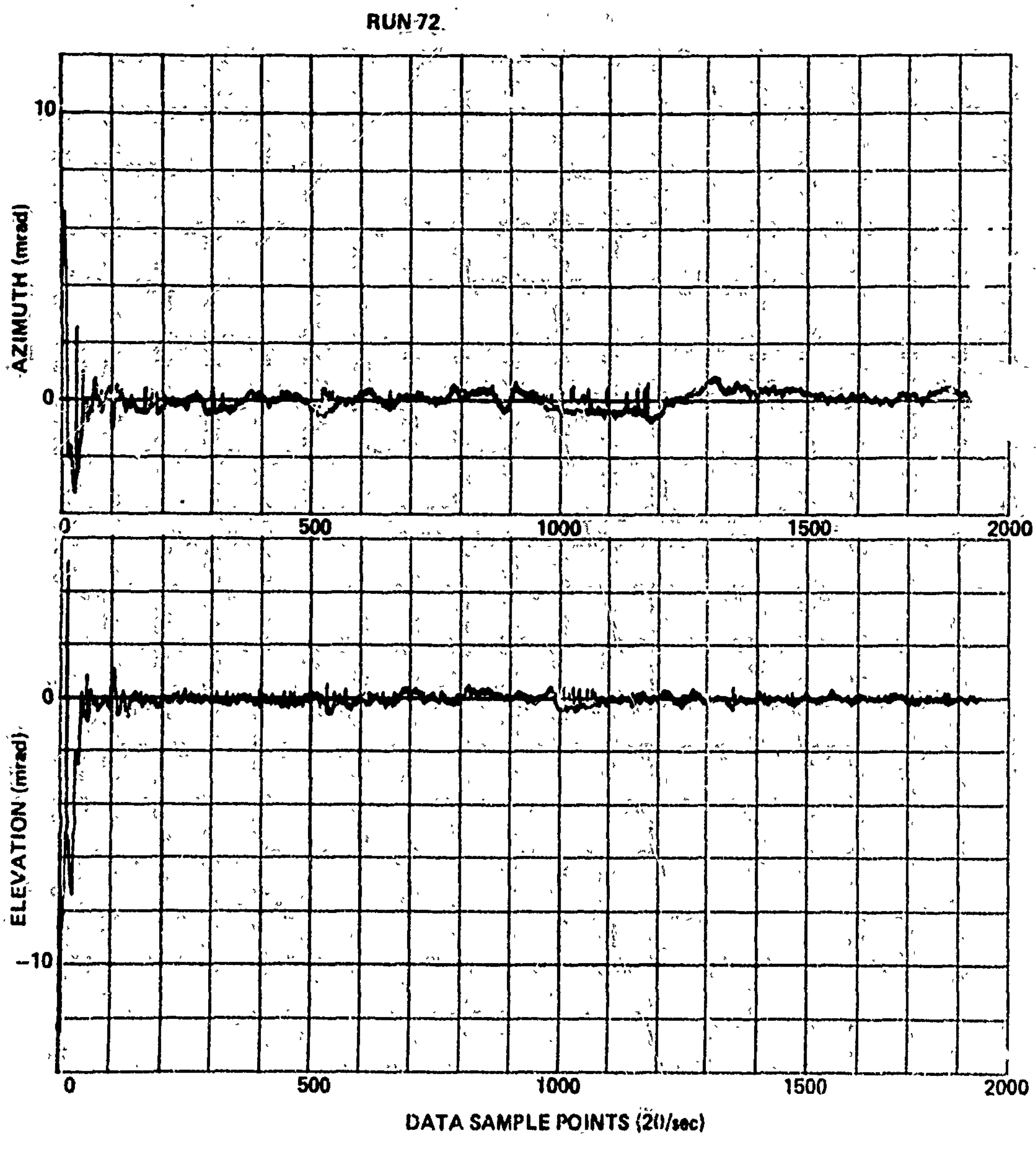
147	F	80	400	321	.0062	-.0027	.2648	.1491	.1827			
148	A	100	600	501	.0066	-.0011	.5002	.2172	.1433			
148	F	100	600	501	.0109	-.0503	.2785	.2692	.1991	.1767		
149		TOO FEW DATA										
170	A	1	530	530	.0059	.0896	.5664	.3237	.0554			
170	F	1	530	530	.0183	-.1240	.3994	.1519	.0976			
171	A	1	1898	1898	.0078	.0726	.6225	.2462	.0520			
171	F	1	1898	1898	.0060	.0254	.5518	.2918	.1547		5	-.1359
172		NONSTATIONARY ERRORS										
173	A	40	320	281	.0094	-.0226	.4094	.3765	.0724		6	-.0501
173	F	40	320	281	.0091	-.0857	.5412	.1802	.1706			
174	A	1	600	600	.0038	.0202	.4119	.2662	.2328			
174	F	1	600	600	.0055	-.0002	.4752	.2882	-.0027	.1531		
175	A	100	500	401	.0213	-.1836	.2622	.2247	.1780		8	.1844
175	F	100	500	401	.0029	.0879	.8338	.1773	-.0891			
176	A	200	500	301	.0028	.2021	.7383	.2501	.0406		10	-.0637
176	F	200	500	301	.0094	-.1054	.3549	.2206	.2185		10	.1179
177	A	1	599	599	.0040	.3372	.6751	.2048	.0784			
177	F	1	599	599	.0103	-.0112	.3458	.2039	.1444		7	.2212
178	A	1	1100	1100	.0096	.0037	.3939	.3117	.2187			
178	F	1	1100	1100	.0166	-.0987	.3066	.2574	.2502			
179	A	150	650	501	.0028	.1784	.6691	.1243	.1330			
179	F	150	650	501	.0043	-.0049	.3331	.2782	.1641		7	.1468
180	A	50	250	201	.0018	.1214	.7568	.1150	.0506			
180	F	50	250	201	.0050	-.0504	.4701	.1844	.1257	.0561		
182	A	1	800	800	.0061	.0529	.4165	.3013	.2035			
182	F	1	900	800	.0044	-.0026	.4478	.2820	.1653			
183	A	1	500	500	.0042	-.0280	.3210	.1871	.1929			
183	F	1	500	500	.0052	.0555	.4090	.1836	.2264			
184	A	1	872	872	.0057	-.0019	.3832	.2416	.2618			
184	F	1	872	872	.0082	-.0233	.3590	.2165	.1441		5	.1846
185	A	1	600	600	.0100	-.0474	.4081	.2589	.1946			
185	F	1	600	600	.0069	.0093	.4598	.2339	.1938			
186	A	100	800	701	.0050	-.0059	.3649	.2877	.1429			
186	F	100	800	701	.0092	-.0521	.4041	.2303	.1892			
187	A	20	399	380	.0047	-.0101	.4461	.0950	.2233			
187	F	20	399	380	.0090	-.0368	.3012	.2523	.1924			
188	A	1	896	896	.0044	-.0049	.3811	.4132	.1418			
188	F	1	896	896	.0059	.0037	.3520	.2206	.1894		6	.1722
189	A	1	800	800	.0020	.0240	.4465	.3001	.1594			
189	F	1	800	800	.0029	.0945	.3021	.2407	.1569	.1464		
190	A	100	650	551	.0063	.1041	.4401	.2761	.0694	.1368		
190	F	100	650	551	.0048	.0552	.4257	.2704	.2091			
191	A	150	450	301	.0050	-.0097	.2077	.2641	.2873			
191	F	150	450	301	.0054	-.0816	.2363	.2411	.1379			
192		TOO FEW DATA										
193	A	50	701	652	.0127	-.1395	.4149	.2855	.1194			
193	F	50	701	652	.0078	-.0699	.4067	.2023	.1470		5	.1159
194	A	200	500	301	.0087	-.0276	.6454	.3026	-.0714			
194	F	200	500	301	.0058	-.0525	.4568	.1929	.2070			
197		NONSTATIONARY ERRORS										
198	A	1	1000	1000	.0061	.0641	.5635	.2508	.2351		6	-.1958
198	F	1	1000	1000	.0153	-.0664	.3462	.2294	.1650			
199	A	320	600	281	.0060	.0801	.6040	.2277	.0553			
199	F	320	600	281	.0065	.0516	.4207	.2985	.1749			
200	A	40	240	201	.0043	.1514	.5389	.2262	.1189			
200	F	40	240	201	.0433	-.1607	.3996	.2530	.0987	.1625		
202	A	100	516	417	.0120	.1549	.5757	.1840	.0439	.1144		
202	F	100	516	417	.0049	-.0586	.3994	.1983	.2033		7	-.0592
203	A	100	1100	1001	.0093	-.0238	.2672	.1955	.1284	.2058		

203	F	100	1100	1001	.0043	.0451	.4235	.1730	.1757		5	.1749
204	A	40	320	281	.0088	.2267	.7140	.1837	-.0262			
204	F	40	320	281	.0098	.1232	.8618	-.0751	-.1867		9	.1294
205	A	60	360	301	.0038	.3490	.6280	.1615	.1349			
205	F	60	360	301	.0069	-.0442	.4280	.1869	.1521			
206		NONSTATIONARY ERRORS										
207	A	80	377	298	.0208	-.0326	.3117	.1995	.0940	.1707		
207	E	80	377	298	.0130	-.0493	.5376	.0182	.1343			
211		NONSTATIONARY ERRORS										
214		NONSTATIONARY ERRORS										
215	A	100	500	401	.0035	.0384	.5459	.2528	.1008		6	-.0538
215	F	100	500	401	.0122	-.0799	.2962	.2748	.1362			
217	A	50	500	451	.0309	.0854	.5270	.2847	.1073			
217	F	50	500	451	.0870	-.0727	.2136	.2614	.1211	.1964		
218	A	50	503	454	.0239	.0331	.3507	.1366	.3642	-.0940		
218	F	50	503	454	.0401	-.1041	.2235	.2598	.0482		5	.1242
219	A	100	604	505	.0025	.0171	.4249	.3383	.0971			
219	F	100	604	505	.0126	-.0736	.2455	.2266	.1811		7	.1964
220		TOO FEW DATA										
221	A	1	750	750	.0049	-.0178	.1926	.1114	.2641	.1347	5	.1657
221	F	1	750	750	.0061	-.0918	.2299	.3279	.2160			
222		TOO FEW DATA										
223	A	100	777	678	.0048	.0792	.6116	.2213	.0460			
223	F	100	777	678	.0080	-.1045	.2126	.2529	.1171	.1690		
227		TOO FEW DATA										
230	A	50	400	351	.0042	-.0324	.3807	.2251	.1637			
230	F	50	400	351	.0080	-.0667	.2035	.1904	.0419			
231		NONSTATIONARY ERRORS										
235	A	80	400	321	.0040	-.0376	.3314	.1237	.1483			
235	F	80	400	321	.0078	-.0267	.4128	.1890	.3090			
236	A	100	550	451	.0038	.0511	.4529	.1393	.1537			
236	F	100	550	451	.0078	-.0354	.3676	.1773	.2951			
3	A	60	300	241	.0033	-.0405	.6078	.0985	-.0436			
3	F	60	300	241	.0029	-.0253	.3663	.1365	.0657			
4		TOO FEW DATA										
155		NONSTATIONARY ERRORS										
156		NONSTATIONARY ERRORS										
158	A	40	340	301	.0175	.0079	.5186	.1595	-.0210			
158	F	40	340	301	.0359	-.1151	.4167	.1200	.0478			
159	A	100	1400	1301	.0125	-.0328	.5253	.1515	.0565	.1141		
159	F	100	1400	1301	.0078	-.0359	.4031	.2413	.0732			
160	A	100	1197	1098	.0089	.0946	.6450	.2358	-.0105			
160	F	100	1197	1098	.0101	-.0686	.4276	.2013	.1809			
161	A	50	500	451	.0173	.0192	.4155	.1222	.1266			
161	F	50	500	451	.0130	-.0387	.3886	.1832	.1886			
273	A	100	450	351	.0014	.0129	.3734	-.0775	.0797		5	-.0827
273	F	100	450	351	.0025	-.0451	.0717	.1303	.1040			
274	A	1	501	501	.0057	.0937	.4547	.2254	.0789	.1260		
274	F	1	501	501	.0049	.0520	.3699	.1851	.2166		5	.1500
275	A	1	626	626	.0030	.0716	.4539	.2571	.1989			
275	F	1	626	626	.0035	-.0256	.4616	.2563	.1478			
276	A	100	500	401	.0057	.0253	.4056	.2926	.2030			
276	F	100	500	401	.0134	-.1145	.1148	.2019	.1265	.2013		
278	A	100	500	401	.0074	.0122	.2891	.3321	.1629			
278	F	100	500	401	.0045	.0631	.2973	.3895	.2159			
279	A	150	526	377	.0061	.0435	.5675	.1297	-.1865	.2088		
279	F	150	526	377	.0061	-.0214	.4449	.2482	.1485			
280		TOO FEW DATA										
294	A	60	675	616	.0210	.1433	.2292	.1483	.1447		6	.2310
294	F	60	675	616	.0330	-.1198	.2693	.1768	.0954			

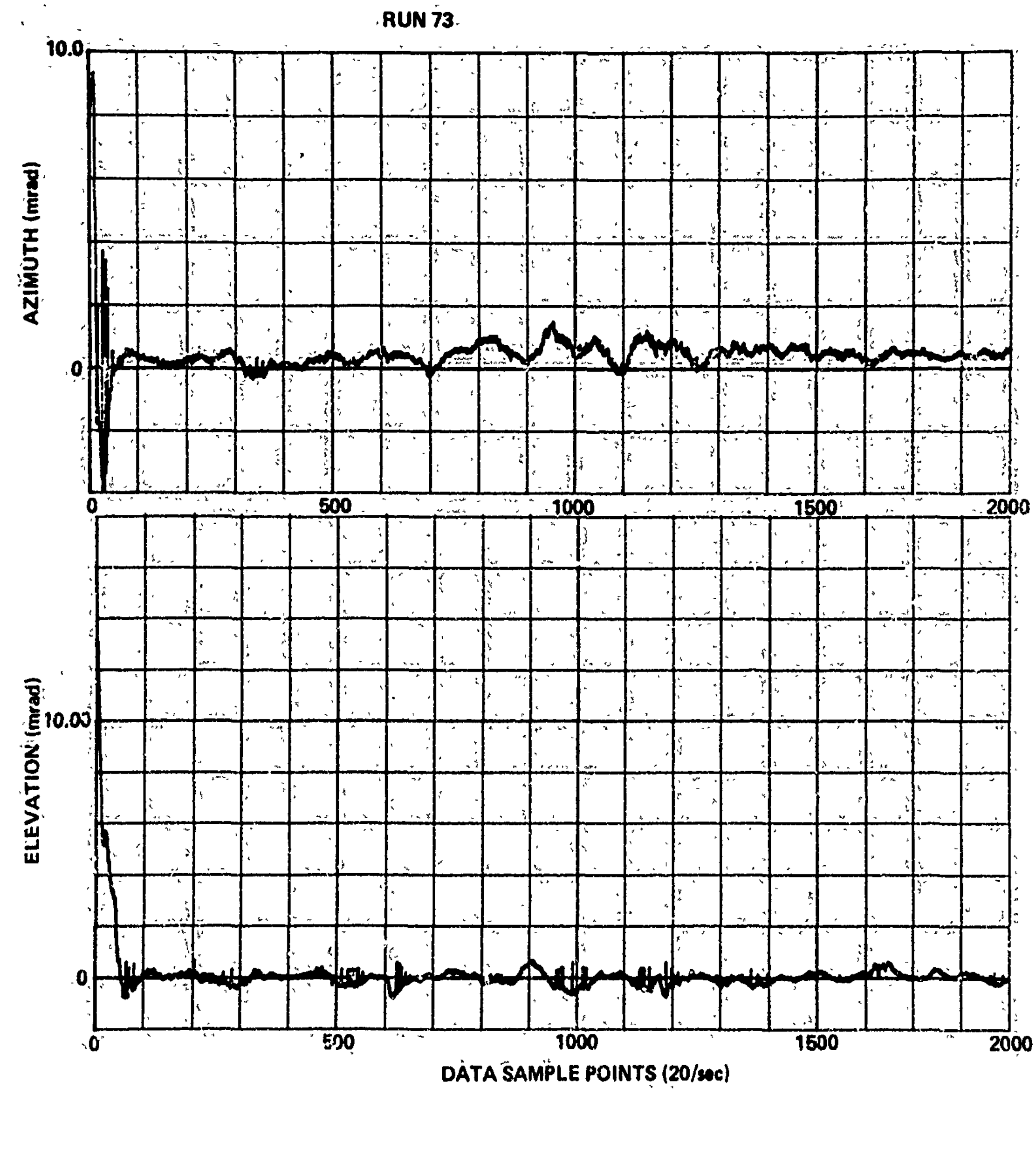
295 A	70	550	481	.0081	.1784	.4123	.2479	.1096	.1209			
295 F	70	550	481	.0156	-.1160	.2491	-.0252	.1004	.1392			
296	NONSTATIONARY ERRORS											
297	TOO FEW DATA											
298 A	50	400	351	.0093	.0462	.3275	.1231	.1831		7	.2177
298 F	50	400	351	.0062	-.0090	.3776	.3094	.0113		7	.0753
300	NONSTATIONARY ERRORS											
301 A	100	426	327	.0095	.0415	.3086	.2236	.0752		9	.1755
301 F	100	426	327	.0075	-.0187	.3315	.1330	.1028		6	.1420
302 A	100	426	327	.0008	-.[illegible]84	.2405	.2364	.2551			
302 F	100	426	327	.0008	.0457	.3506	.2688	.0878		6	.1021
303 A	1	450	450	.0079	.2411	.3908	.2531	.2373			
303 F	1	450	450	.0096	-.0578	.3478	.2464	.0861	.1792		
305	NONSTATIONARY ERRORS											
306	NONSTATIONARY ERRORS											
307 A	100	476	377	.0066	.3582	.3902	.1418	.2037		5	.1325
307 F	100	476	377	.0277	-.1769	.0900	.0809	.1051		5	.1182
308	TOO FEW DATA											
309 A	1	501	501	.0162	.1636	.2896	.1772	.1398		6	.1091
309 F	1	501	501	.0045	.0135	.4356	.1597	.1871		6	-.0317
311 A	100	600	501	.0058	.1495	.2518	.2818	.2413			
311 F	100	600	501	.0055	-.0446	.3140	.1270	.1909			
312 A	100	1059	960	.0019	.0387	.3731	.4848	.0037	.0277		
312 F	100	1059	960	.0036	-.0025	.5615	.2175	.0549		11	.0573
313 A	50	1200	1151	.0027	.0614	.4023	.4314	.0958		9	-.0026
313 F	50	1200	1151	.0095	-.0714	.3128	.1286	.1214		5	.1666
314 A	50	1166	1117	.0031	.0654	.5059	.3424	.0300			
314 F	50	1166	1117	.0063	-.0322	.4253	.2750	.1384			
315 A	120	1653	1534	.0032	.0366	.5541	.4116	-.0463			
315 F	120	1653	1534	.0076	-.0611	.3754	.2899	.1451			
316 A	200	1400	1201	.0044	.0035	.2834	.2784	.2146	.1485		
316 F	200	1400	1201	.0095	-.0897	.3209	.1710	.1309	.1795		
317 A	100	1500	1401	.0057	-.0298	.4104	.2352	.1493		7	.1046
317 F	100	1500	1401	.0118	-.0950	.3559	.2604	.2604			
318 A	150	700	551	.0037	.0084	.4065	.3131	.0978			
318 F	150	700	551	.0154	-.0663	.3288	.2745	.0898			
319 A	80	698	619	.0053	.0668	.4666	.2379	.1025		6	.1172
319 F	80	698	619	.0106	-.0494	.3130	.2534	.2079		6	.0851
320 A	50	1021	972	.0041	.0630	.3969	.2223	.1647	.1233		
320 F	50	1021	972	.0068	-.0660	.3730	.2447	.1993			

6. Data Plots

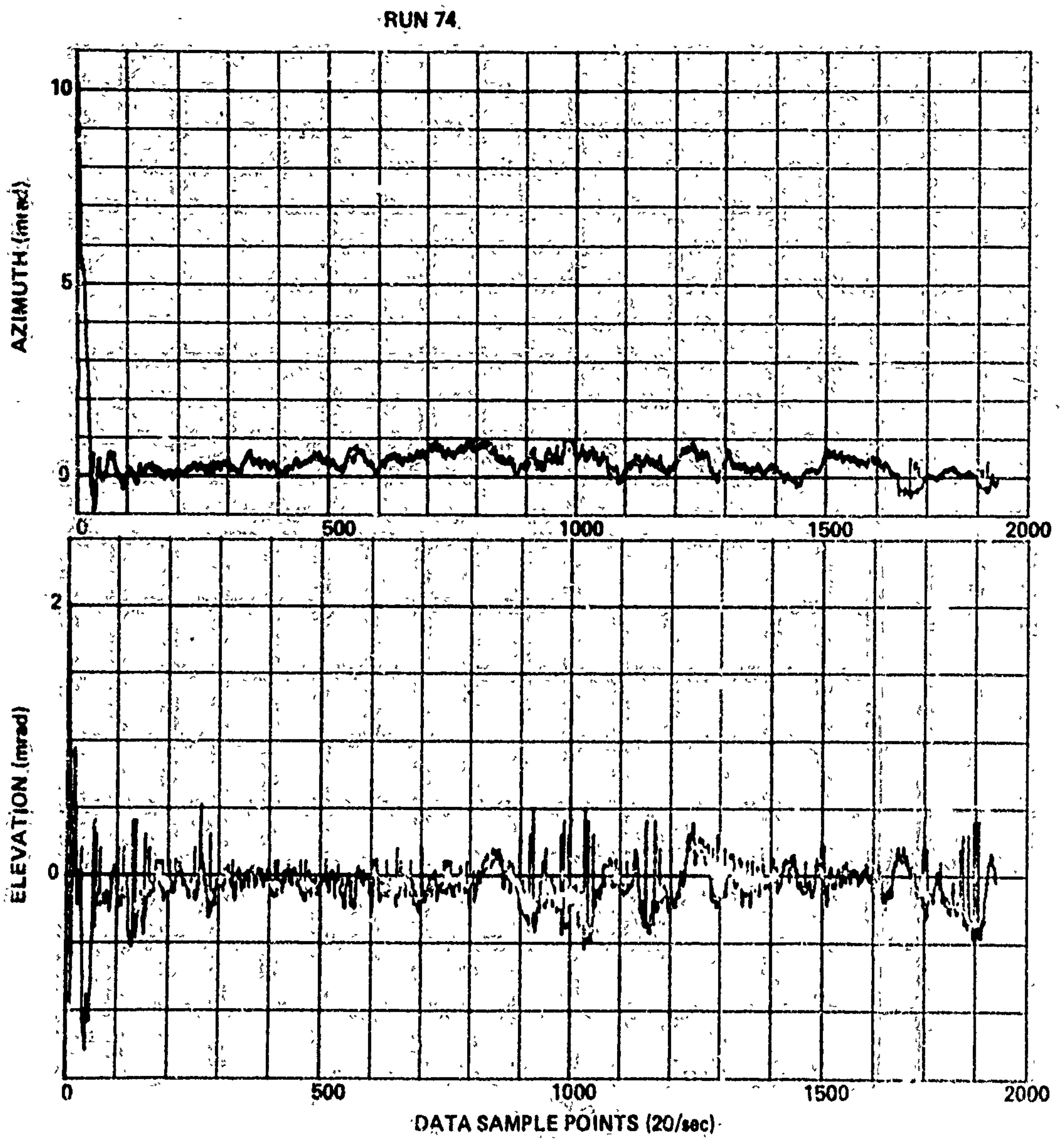

RUN 71
AZIMUTH (mrad)
5
0
0
500
1000
1500
2000
ELEVATION (mrad)
10
0
−10
0
500
1000
1500
2000
DATA SAMPLE POINTS (20/sec)



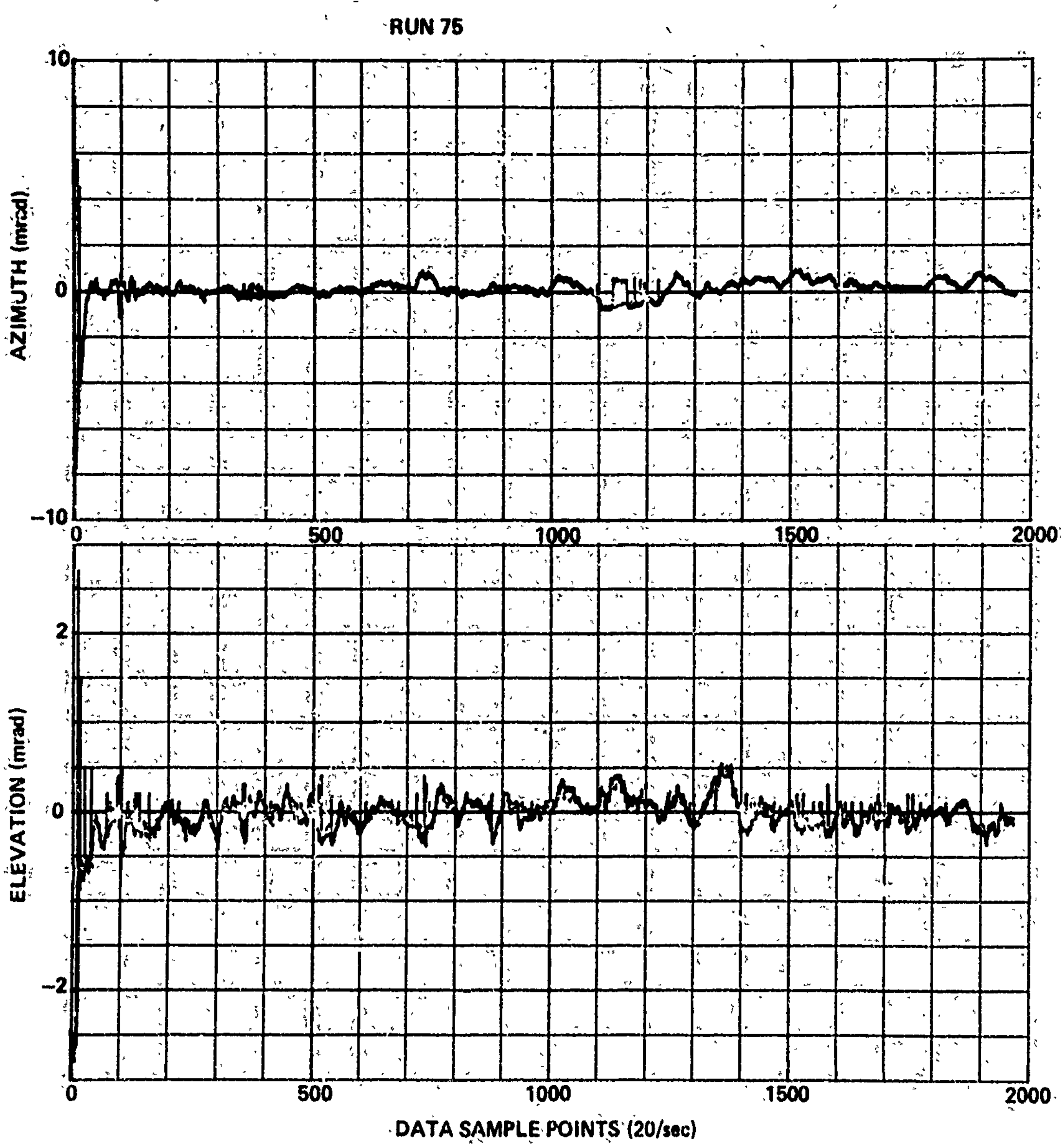
RUN 72
AZIMUTH (mrad)
10
0
0
500
1000
1500
2000
ELEVATION (mrad)
0
−10
0
500
1000
1500
2000
DATA SAMPLE POINTS (20/sec)

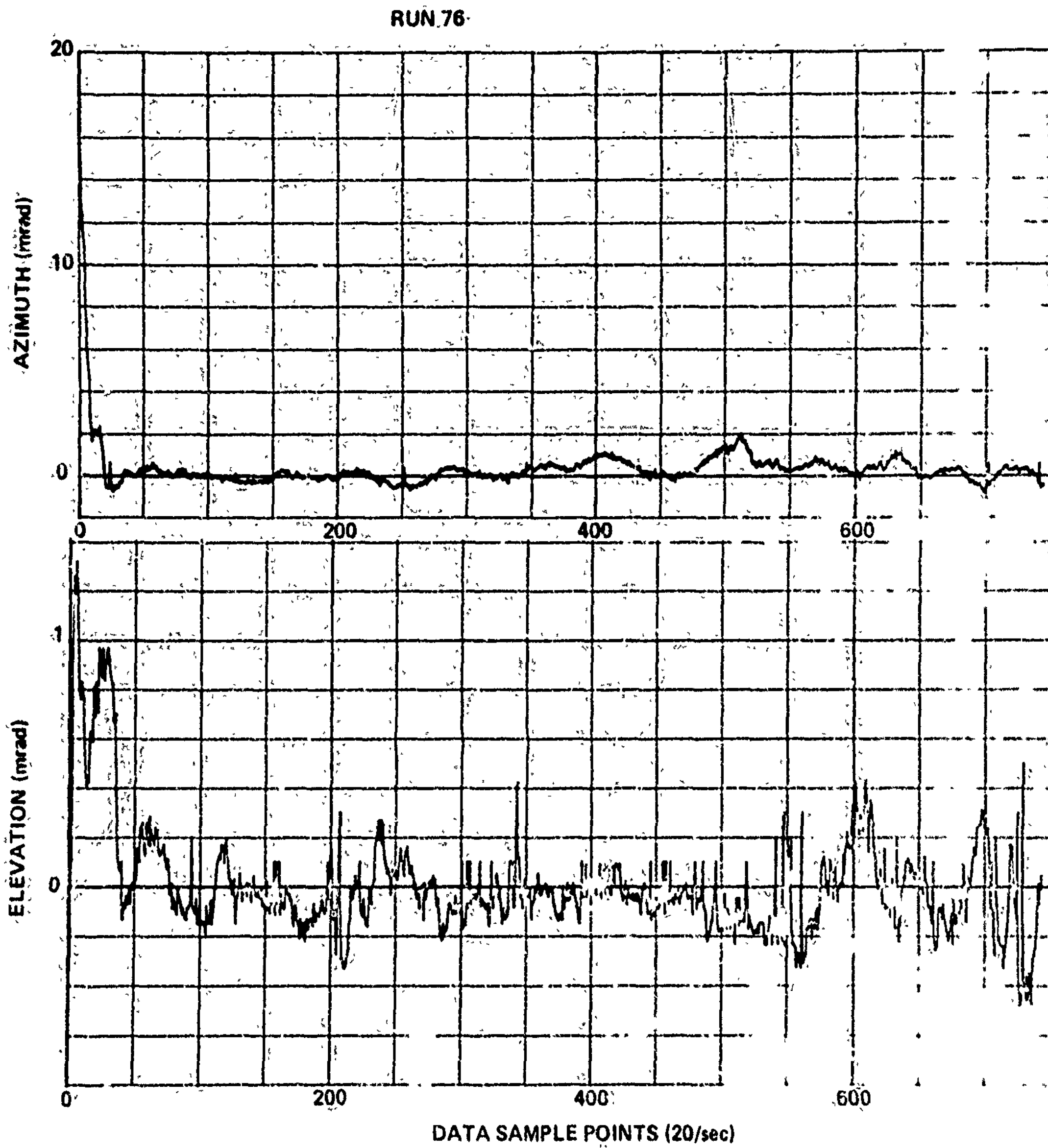


RUN 73
10.0
AZIMUTH (mrad)
0
0
500
1000
1500
2000
ELEVATION (mrad)
10.00
0
0
500
1000
1500
2000
DATA SAMPLE POINTS (20/sec)



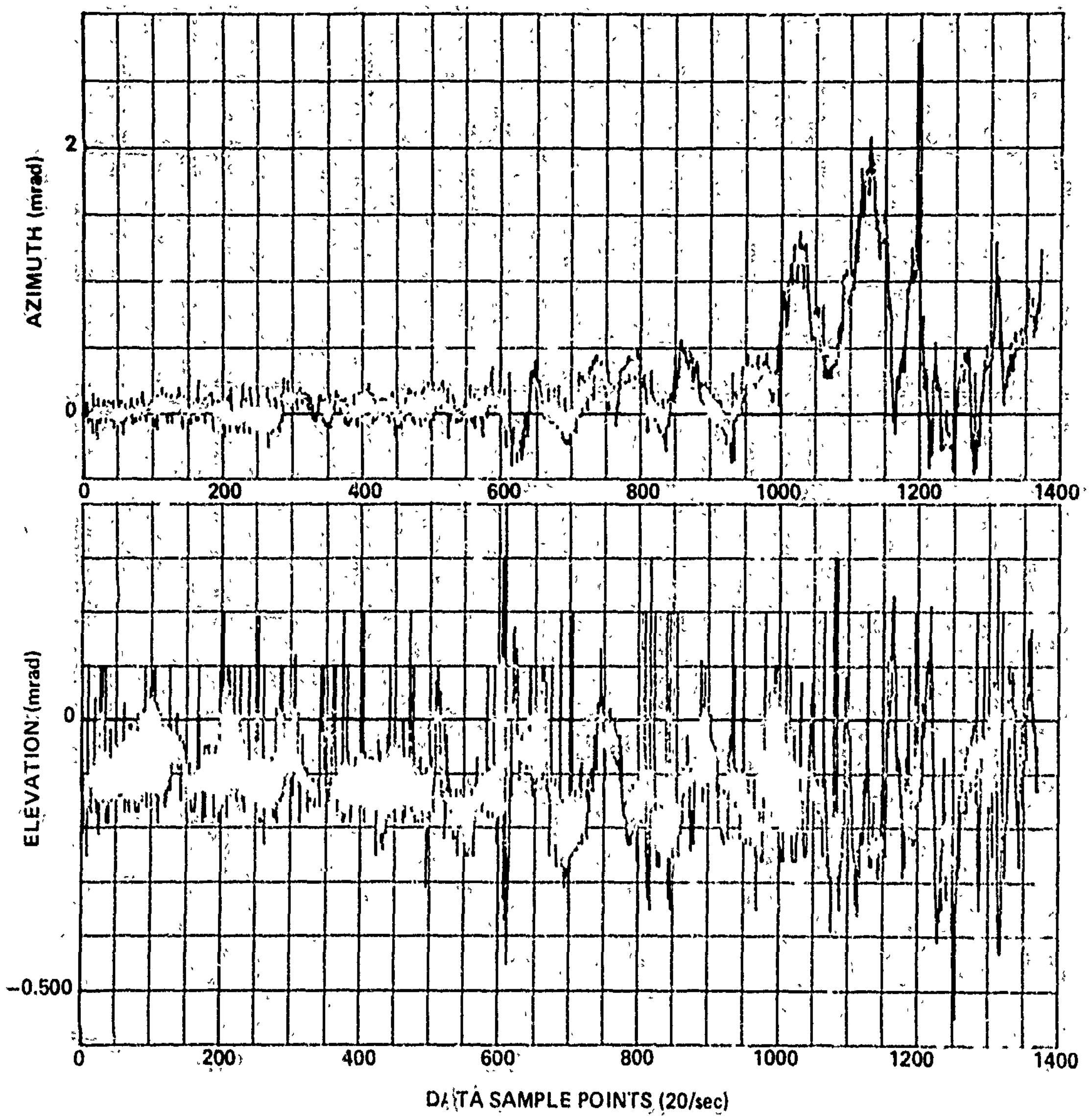
RUN 74
AZIMUTH (mrad)
10
5
0
0
500
1000
1500
2000
ELEVATION (mrad)
2
0
0
500
1000
1500
2000
DATA SAMPLE POINTS (20/sec)

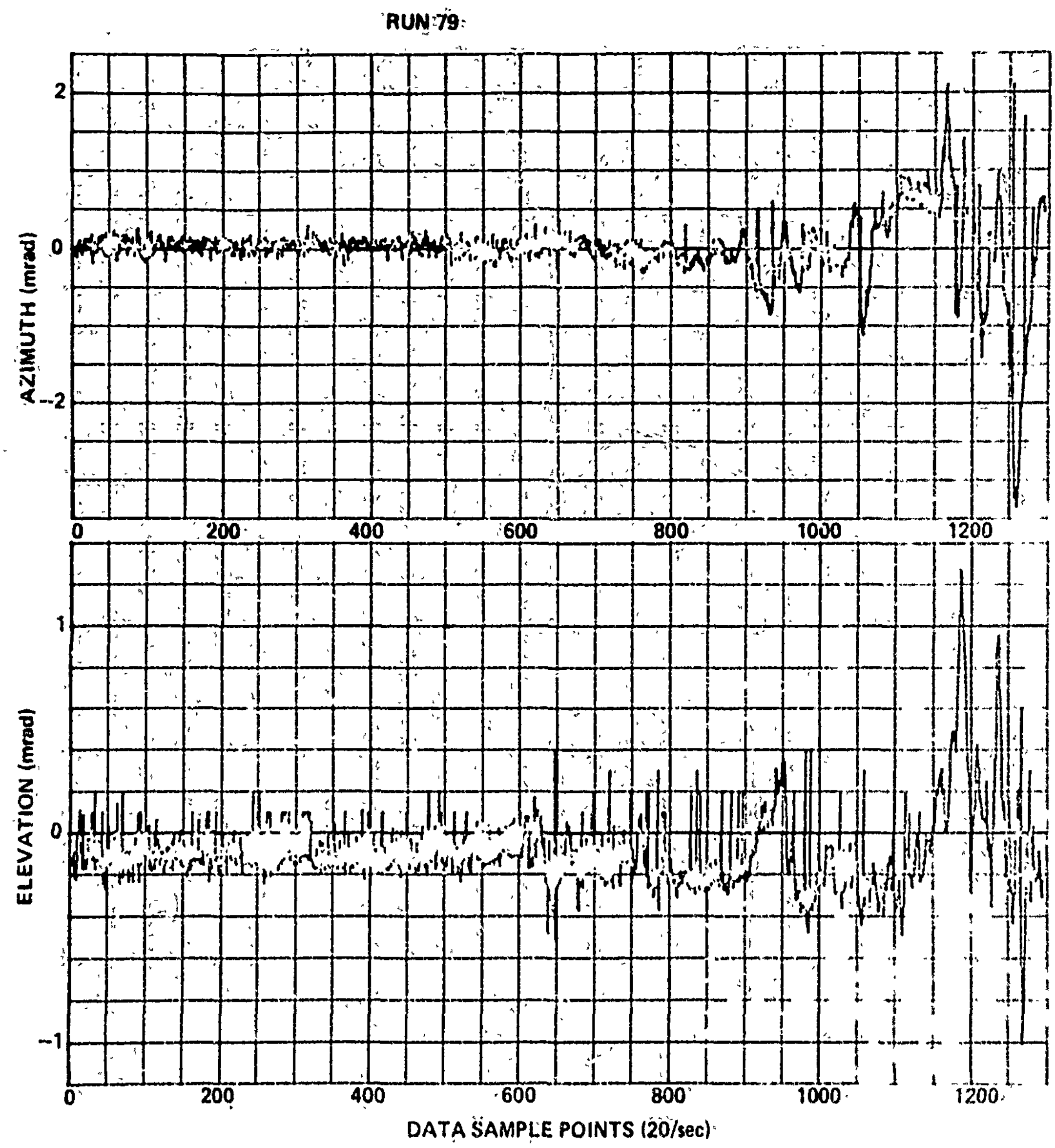

RUN 75
10
0
-10
AZIMUTH (mrad)
0
500
1000
1500
2000
2
0
-2
ELEVATION (mrad)
0
500
1000
1500
2000
DATA SAMPLE POINTS (20/sec)



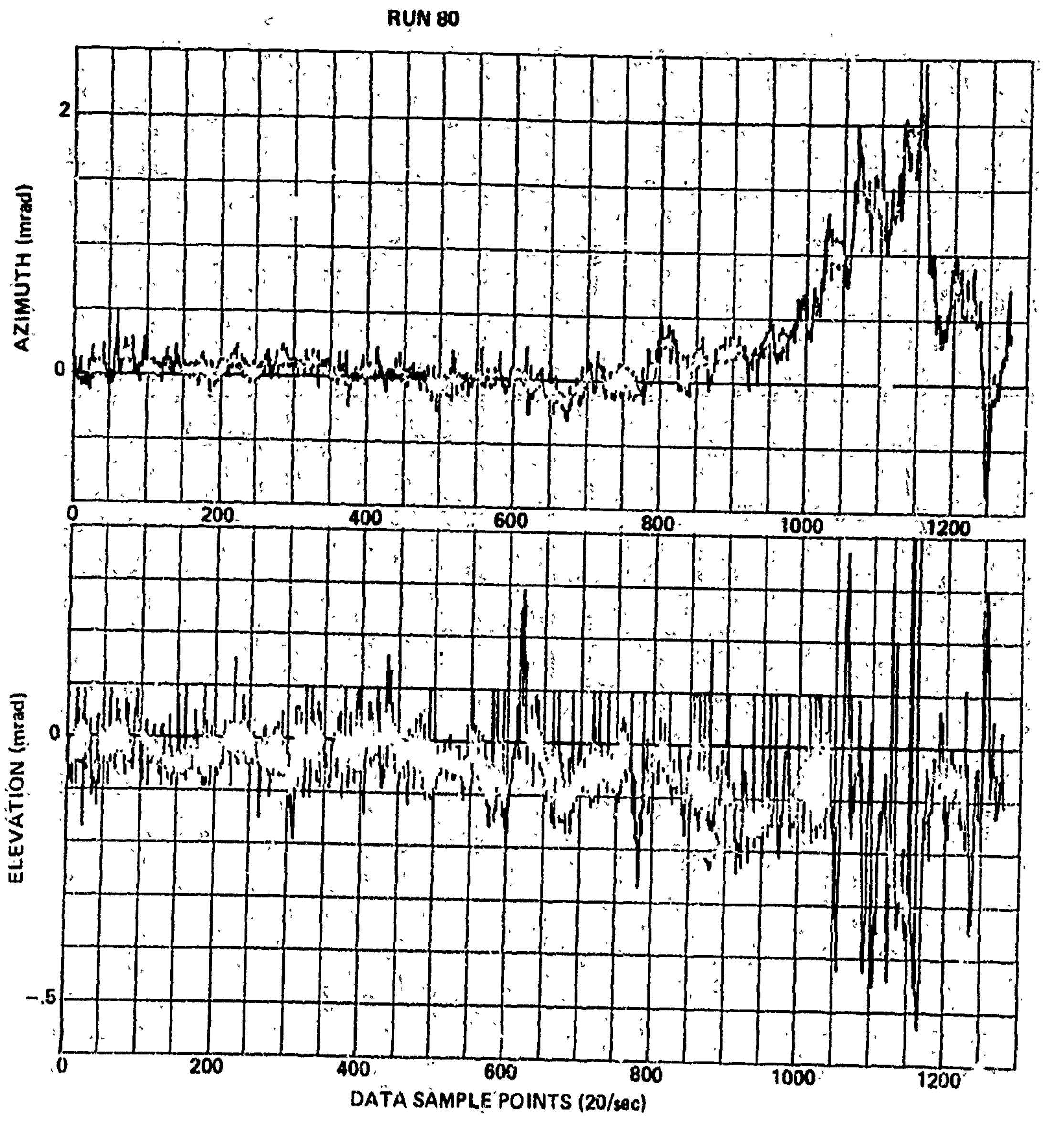
RUN 76
20
10
0
AZIMUTH (mrad)
0
200
400
600
.1
0
ELEVATION (mrad)
0
200
400
600
DATA SAMPLE POINTS (20/sec)

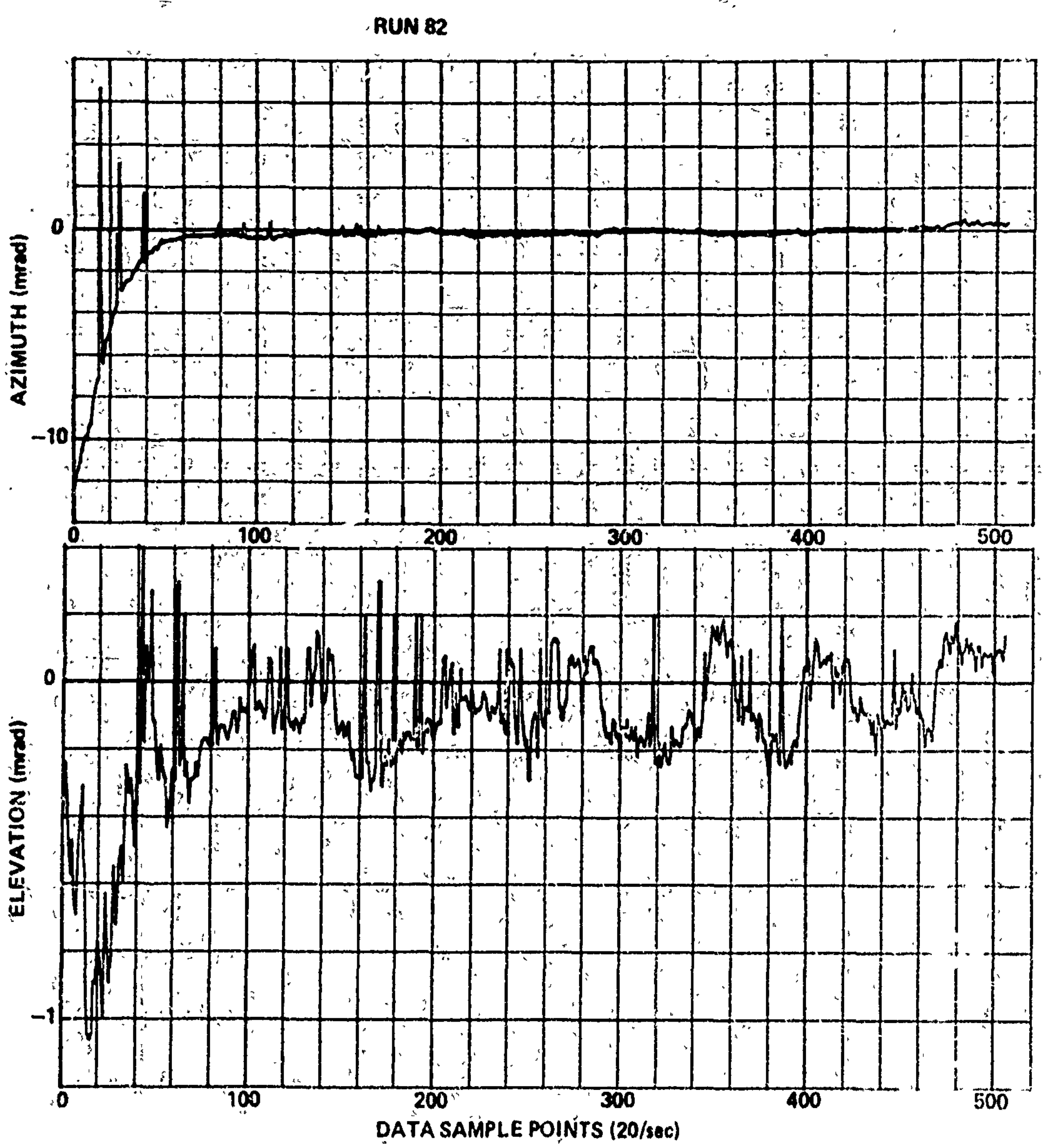
RUN 77


AZIMUTH (mrad)
2
0
0
200
400
600
800
1000
1200
1400
ELEVATION (mrad)
0
−0.500
0
200
400
600
800
1000
1200
1400
DATA SAMPLE POINTS (20/sec)

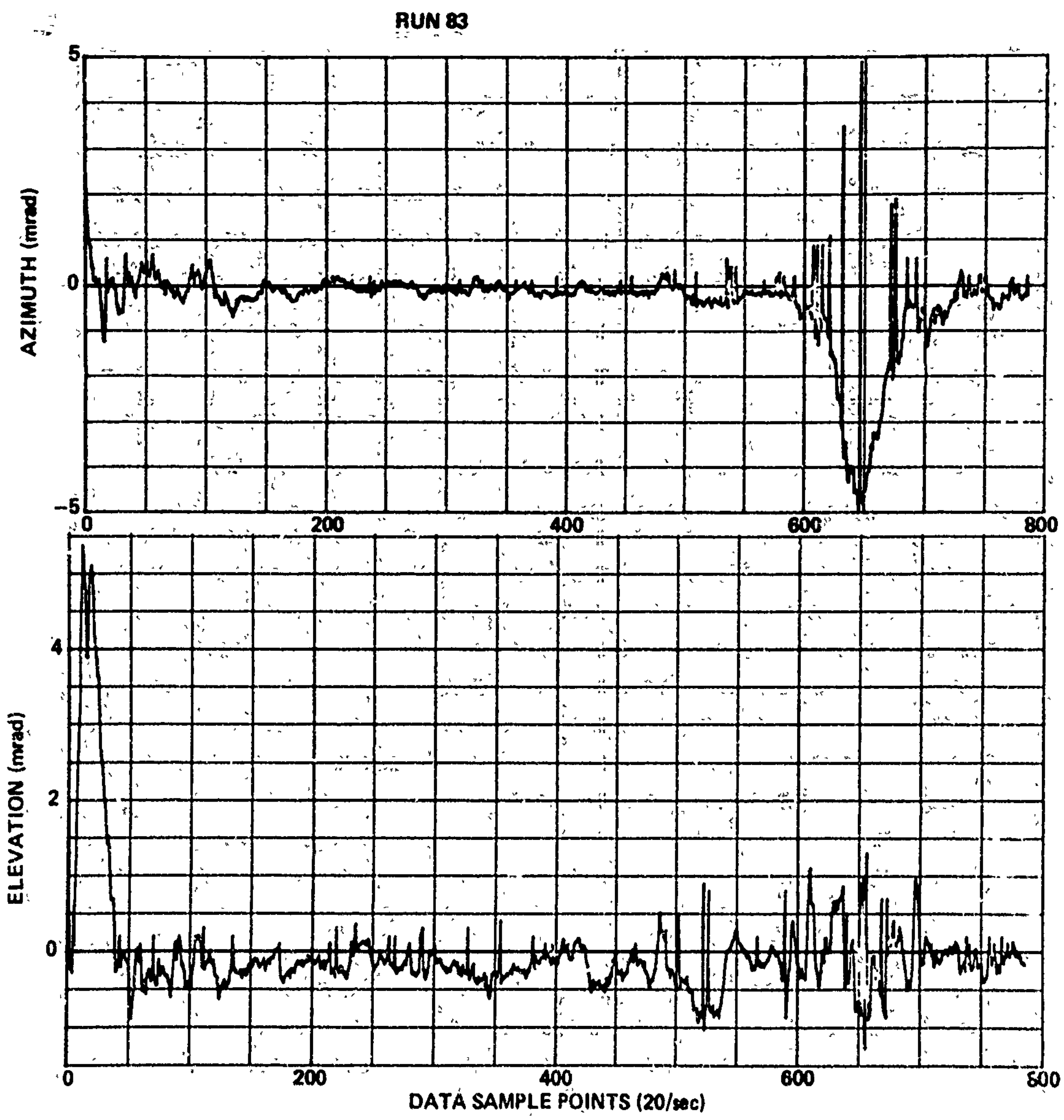


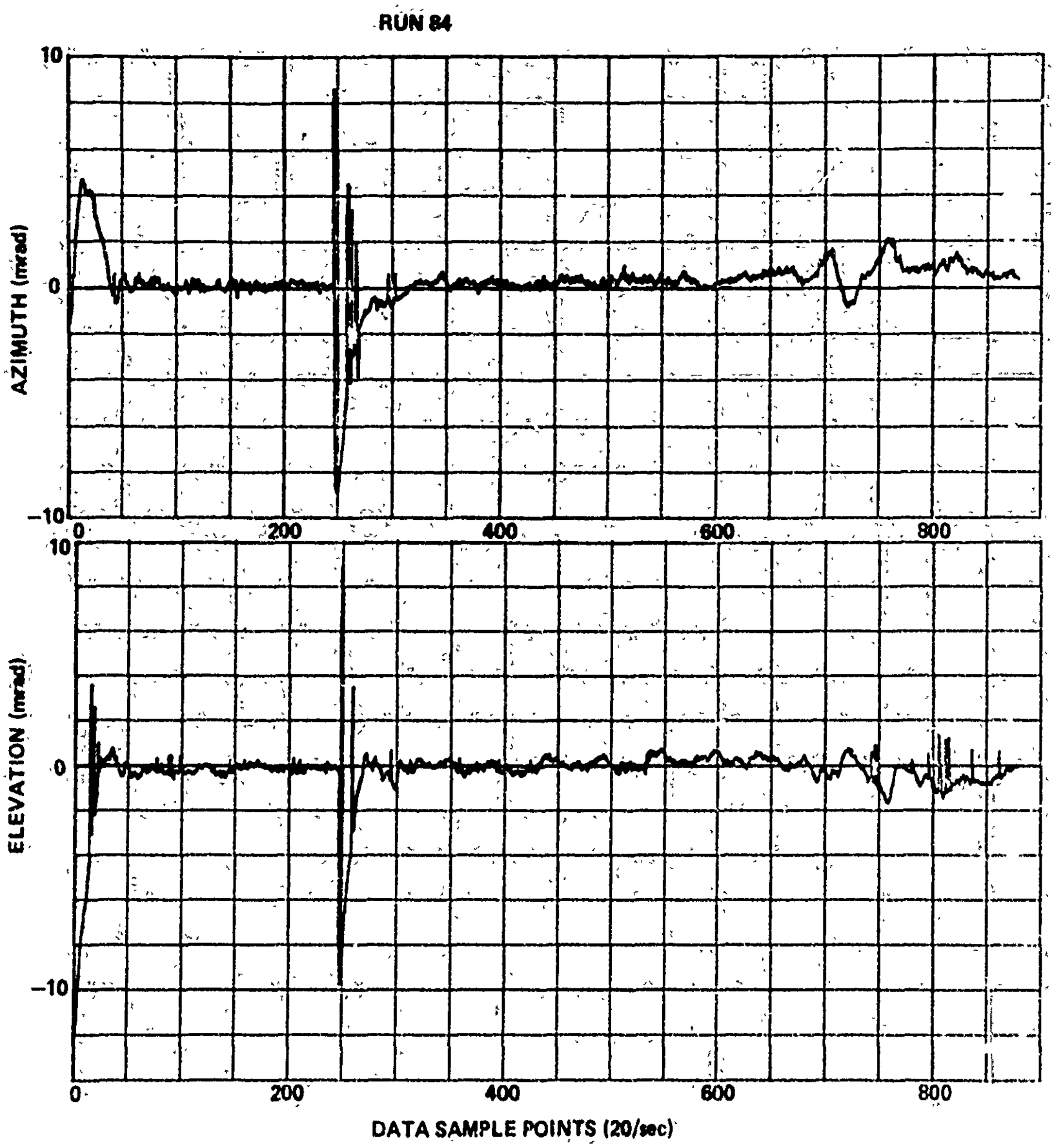
RUN 79
AZIMUTH (mrad)
2
0
−2
0
200
400
600
800
1000
1200
ELEVATION (mrad)
1
0
−1
DATA SAMPLE POINTS (20/sec)

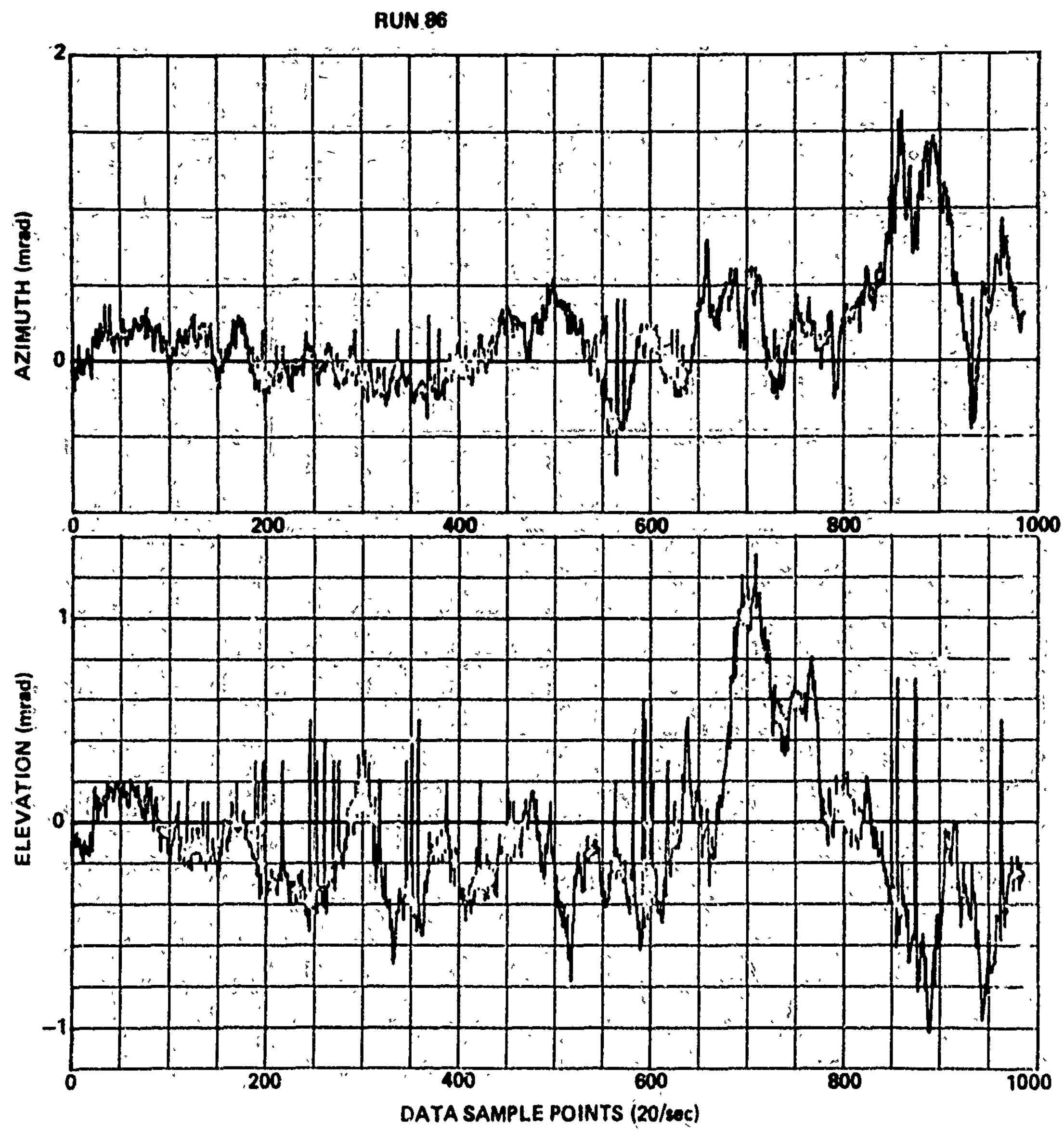

RUN 80
AZIMUTH (mrad)
2
0
0
200
400
600
800
1000
1200
ELEVATION (mrad)
0
-.5
0
200
400
600
800
1000
1200
DATA SAMPLE POINTS (20/sec)

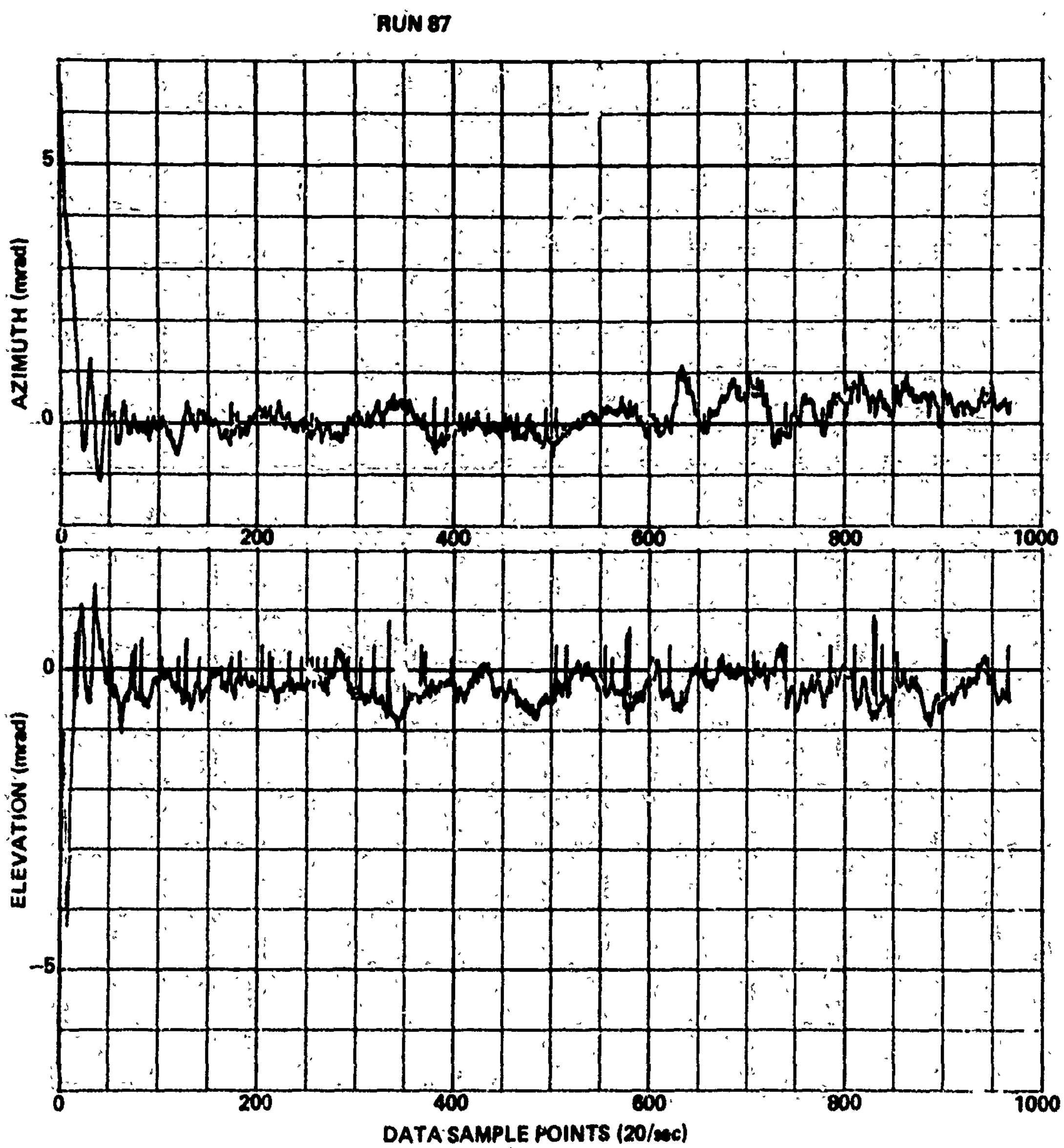


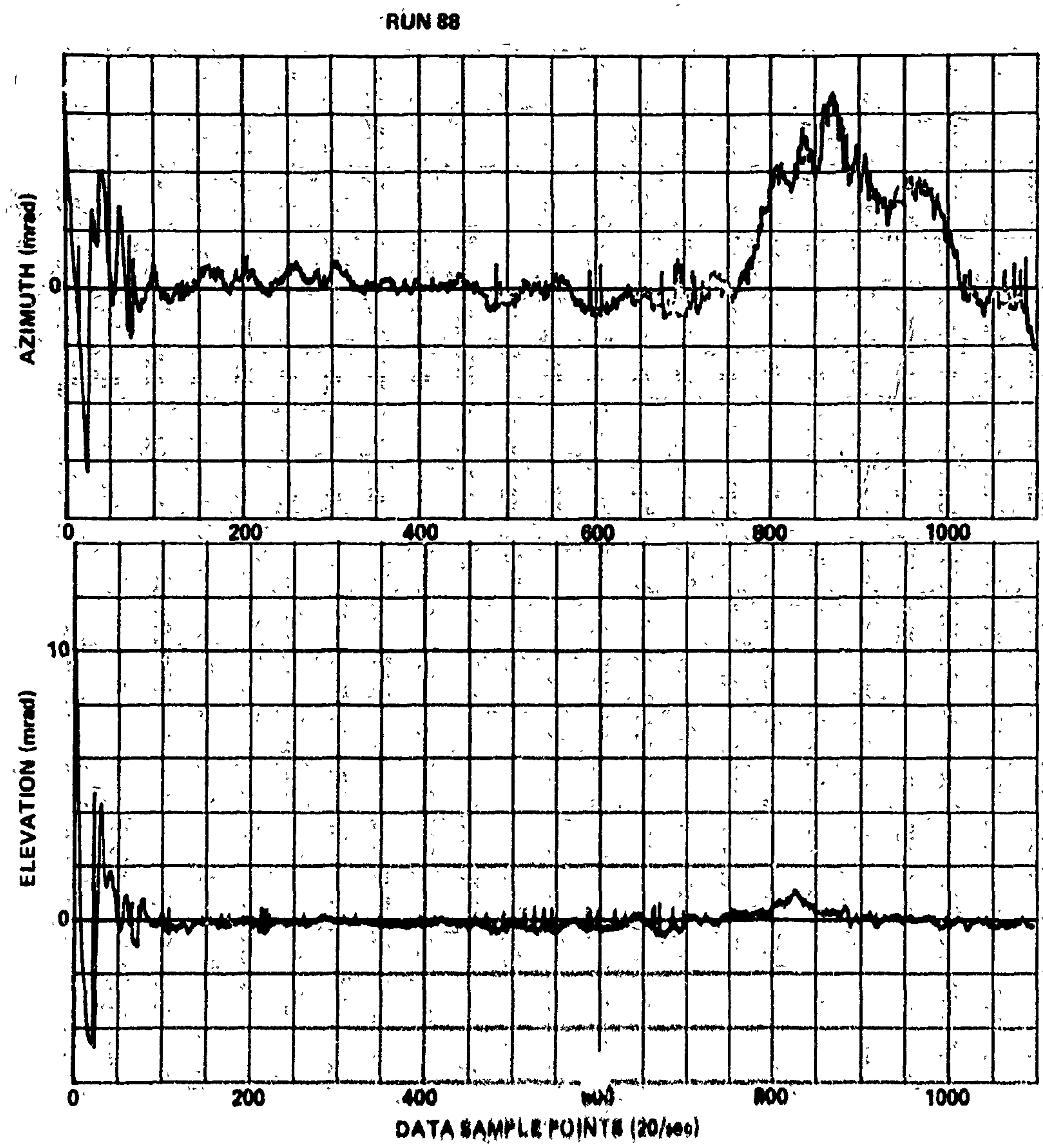
RUN 82
AZIMUTH (mrad)
0
−10
0
100
200
300
400
500
ELEVATION (mrad)
0
−1
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)


RUN 83
5
0
−5
AZIMUTH (mrad)
0
200
400
600
800
4
2
0
ELEVATION (mrad)
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

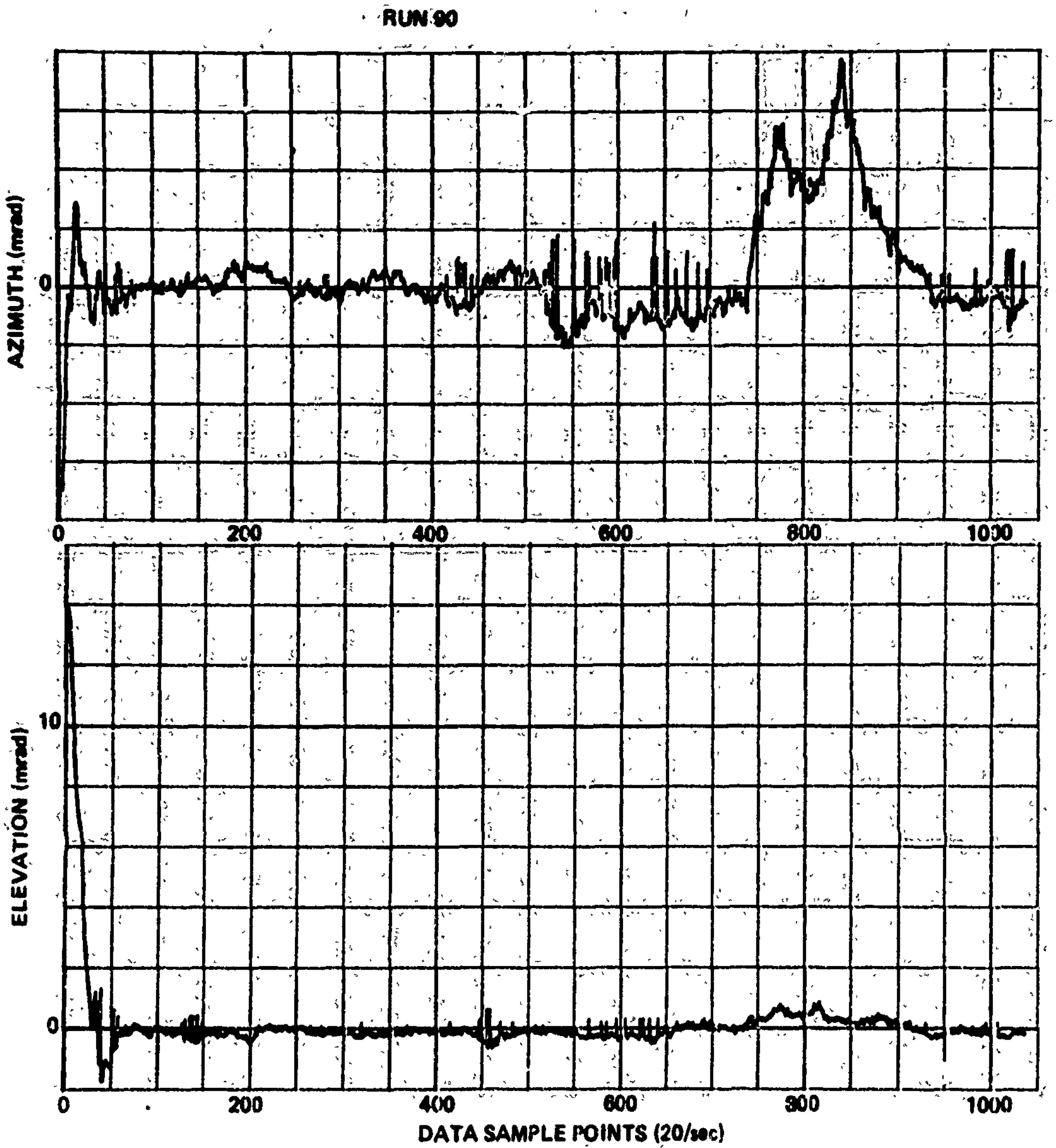

RUN 84
AZIMUTH (mrad)
10
0
−10
0
200
400
600
800
ELEVATION (mrad)
10
0
−10
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

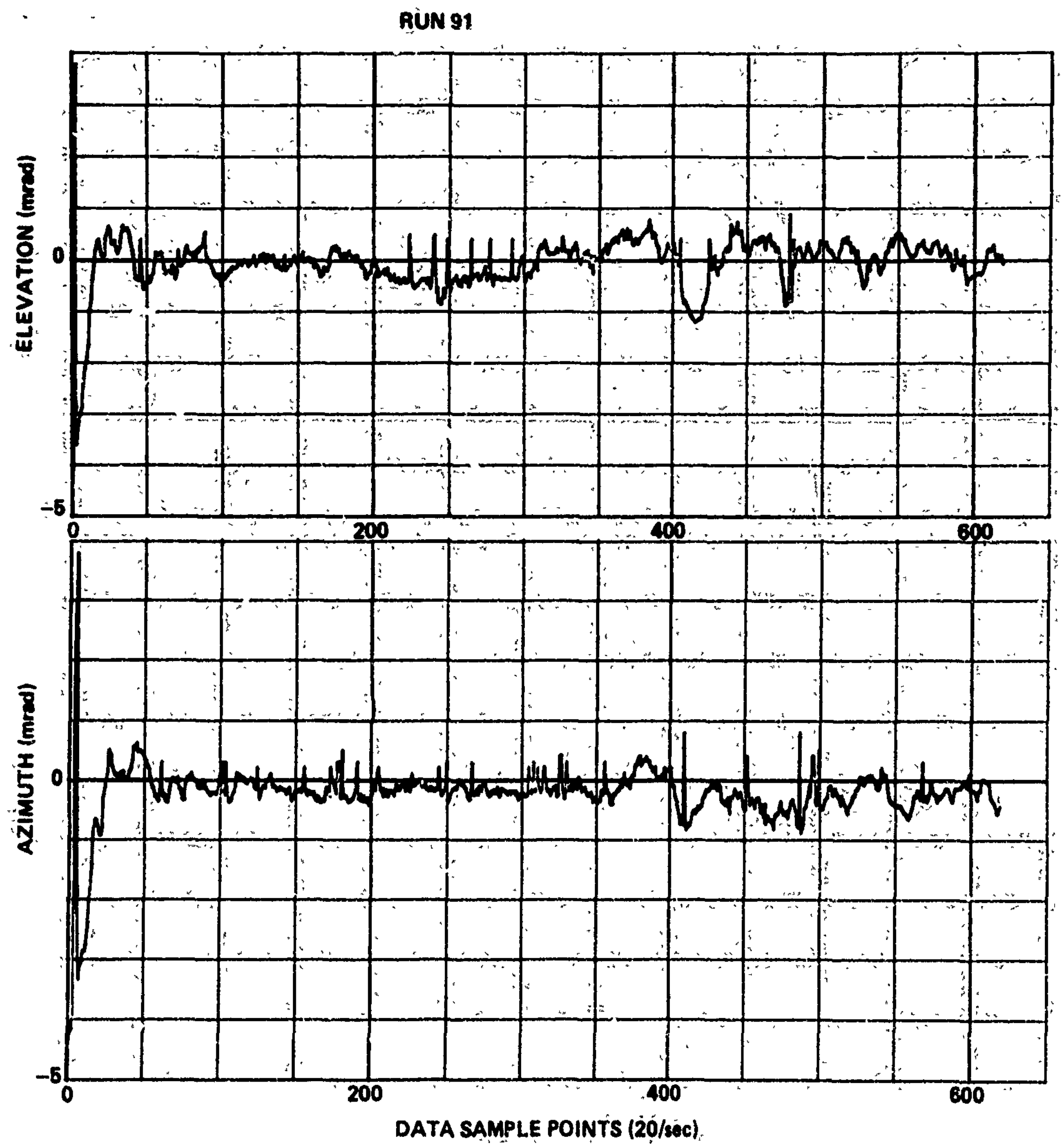

RUN 86
AZIMUTH (mrad)
2
0
0
200
400
600
800
1000
ELEVATION (mrad)
1
0
−1
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)


RUN 87
AZIMUTH (mrad)
5
0
0
200
400
600
800
1000
ELEVATION (mrad)
0
-5
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)

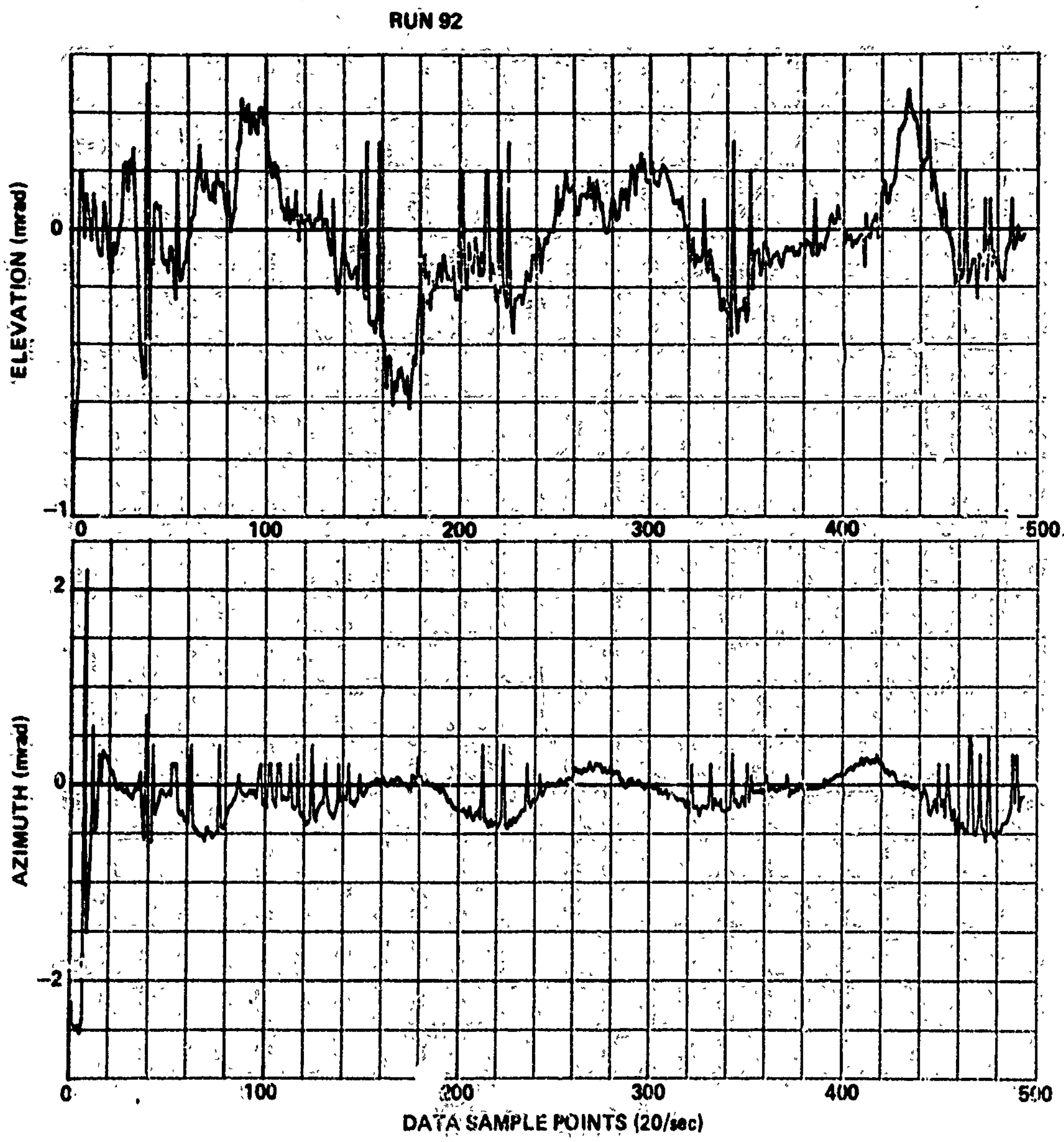


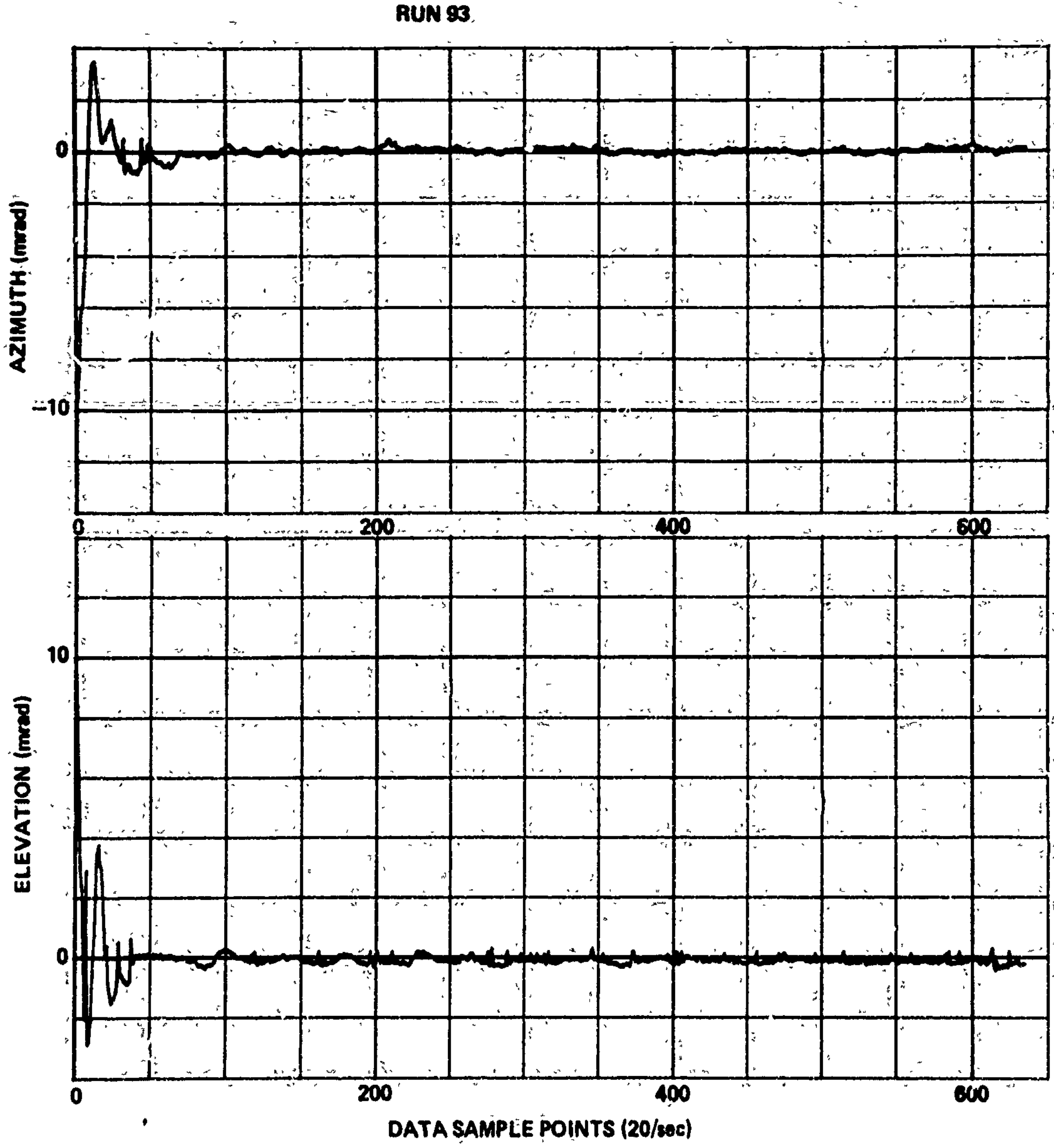
RUN 88
AZIMUTH (mrad)
0
200
400
600
800
1000
ELEVATION (mrad)
10
0
DATA SAMPLE POINTS (20/sec)


RUN 90
AZIMUTH (mrad)
0
0
200
400
600
800
1000
ELEVATION (mrad)
10
0
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)

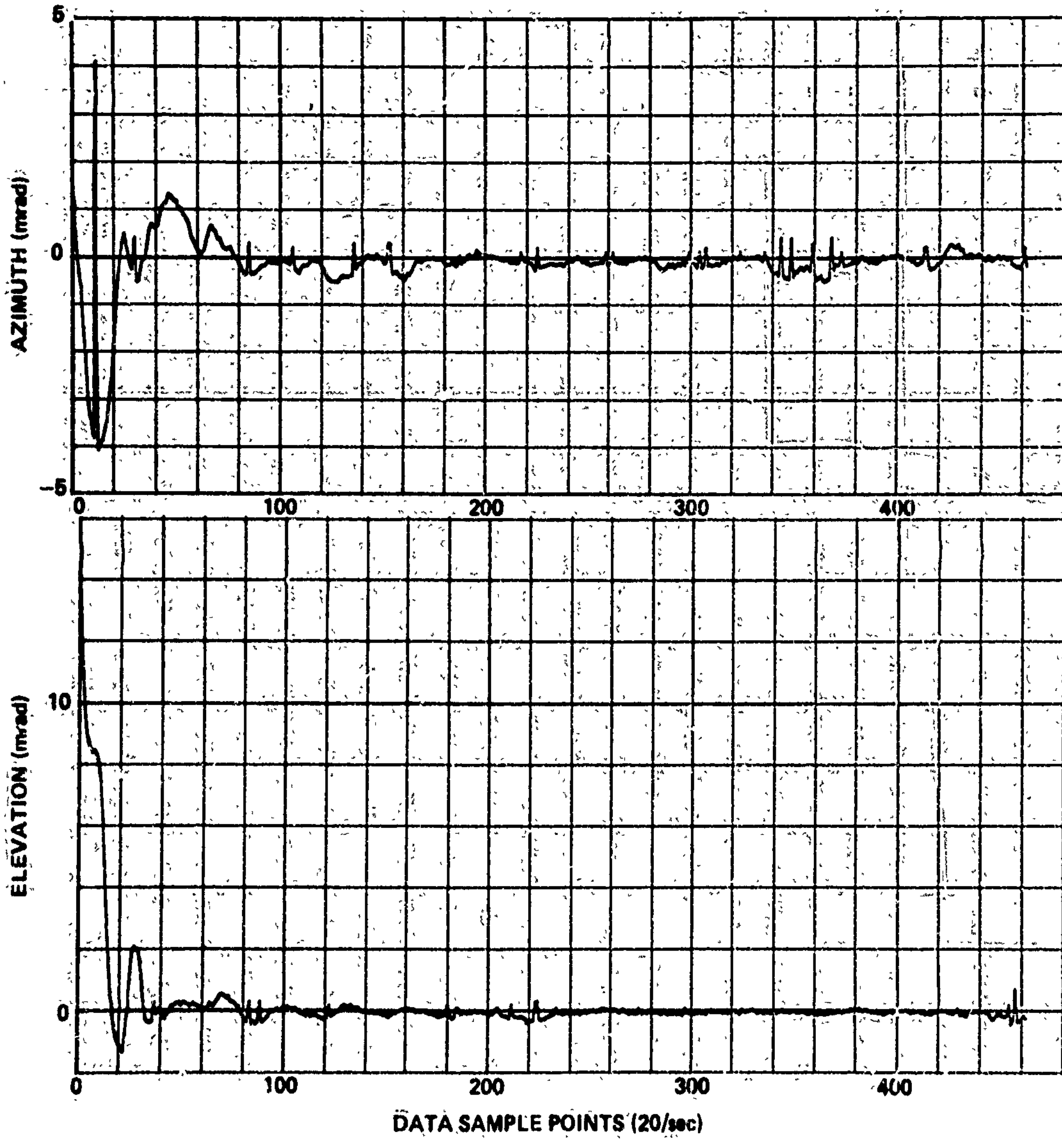


RUN 91
ELEVATION (mrad)
0
-5
0
200
400
600
AZIMUTH (mrad)
0
-5
0
200
400
600
DATA SAMPLE POINTS (20/sec)

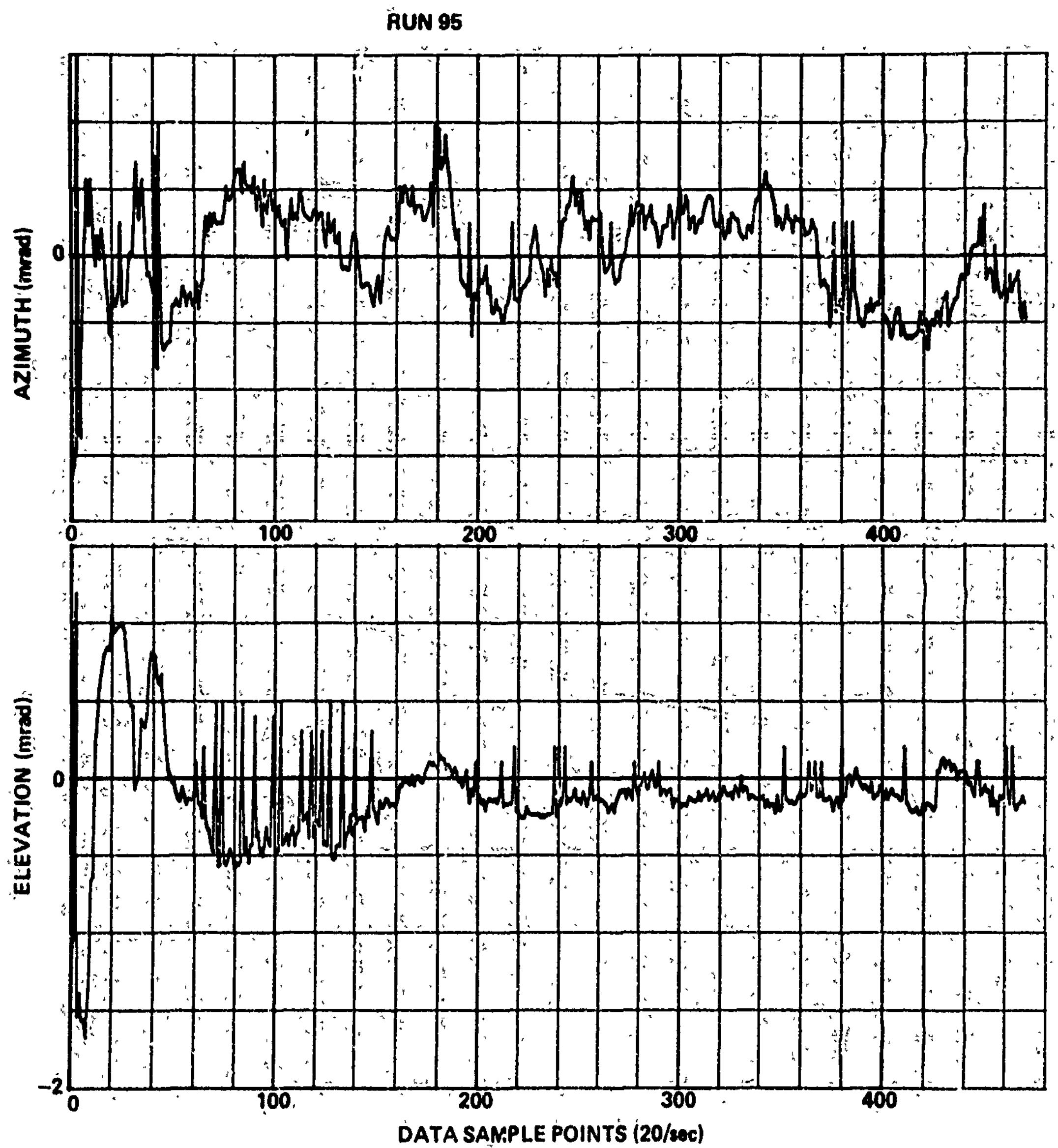

RUN 92
ELEVATION (mrad)
0
−1
0
100
200
300
400
500
AZIMUTH (mrad)
2
0
−2
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

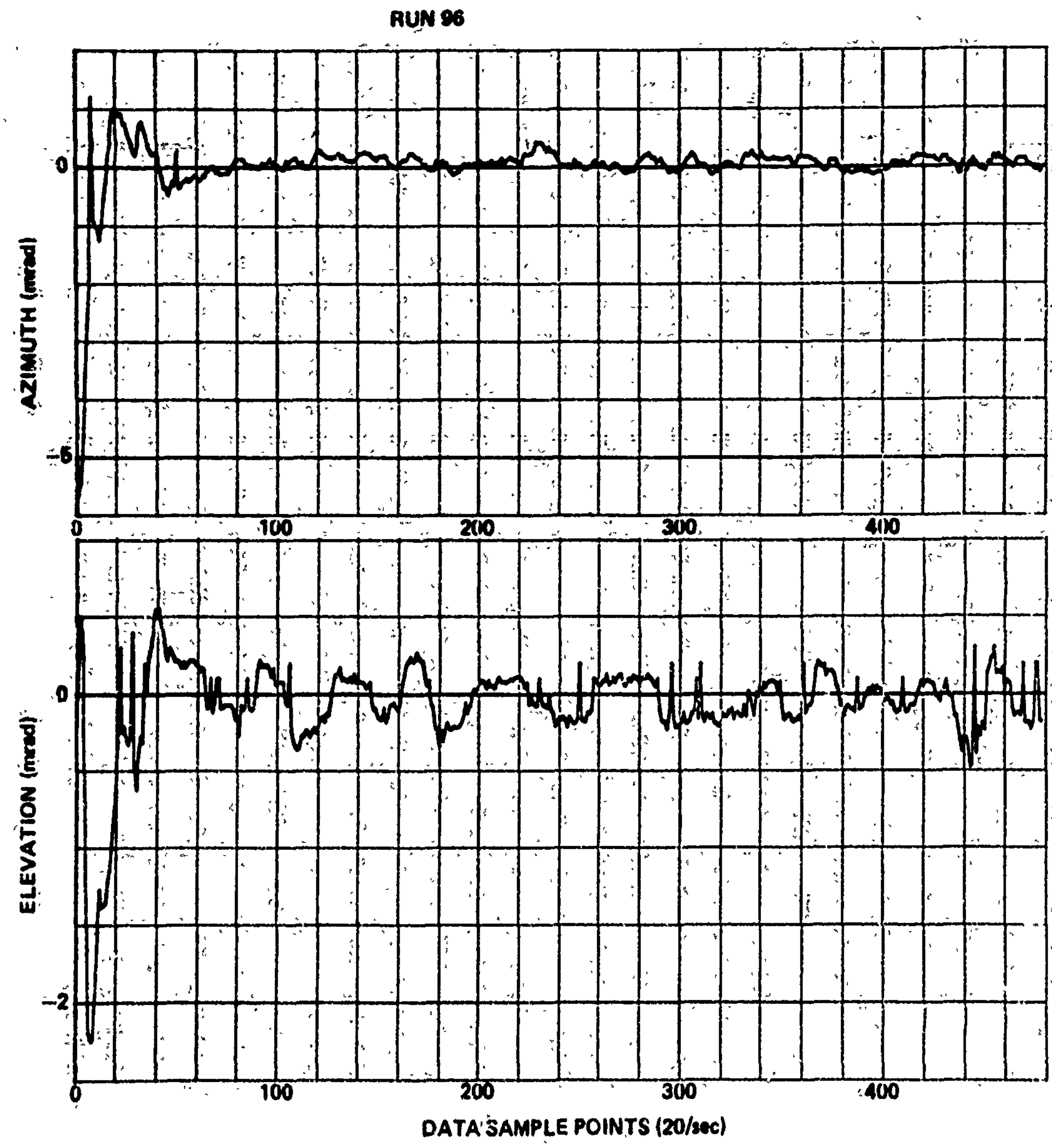

RUN 93
AZIMUTH (mrad)
0
-10
0
200
400
600
ELEVATION (mrad)
10
0
0
200
400
600
DATA SAMPLE POINTS (20/sec)

RUN 94

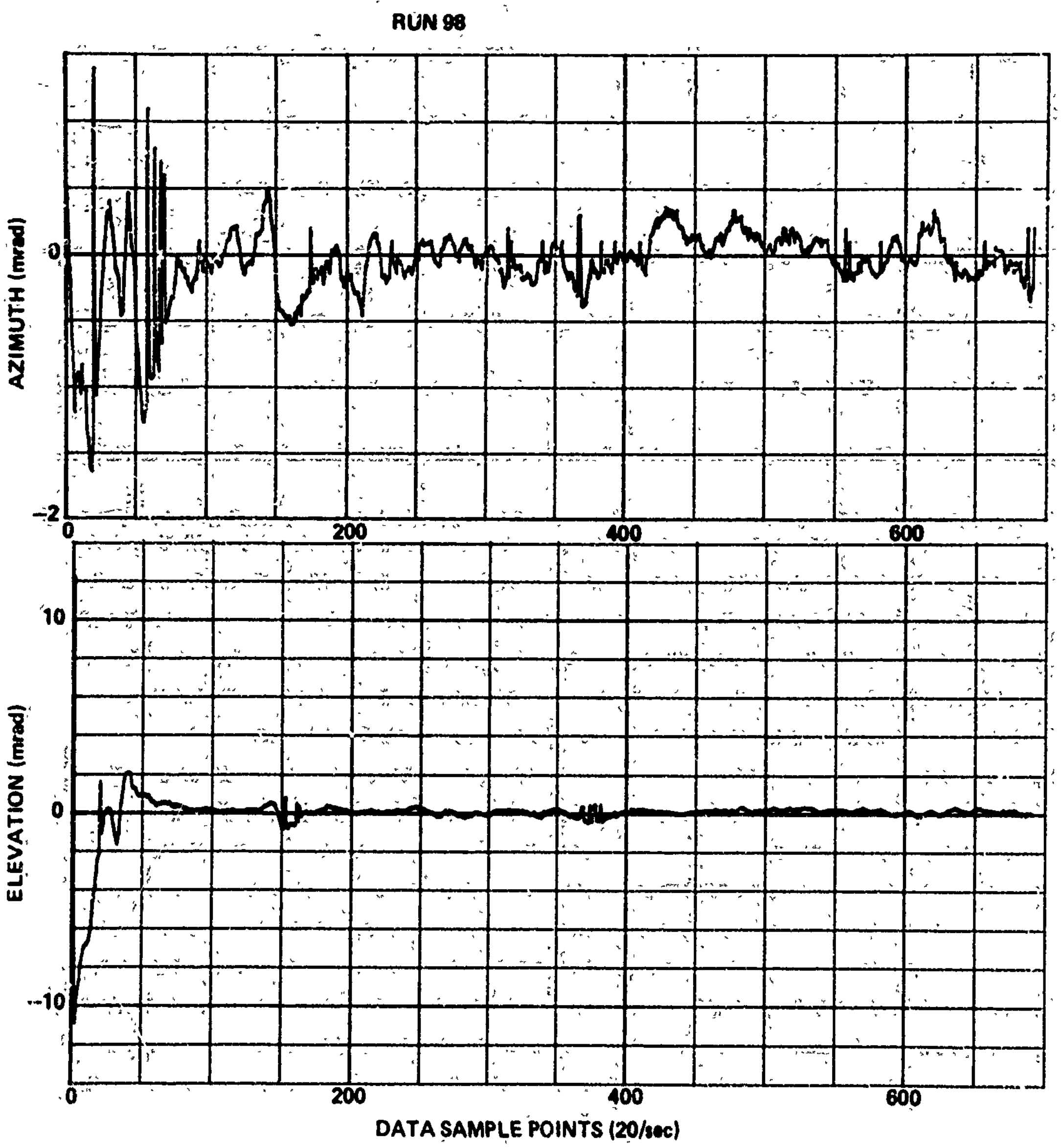


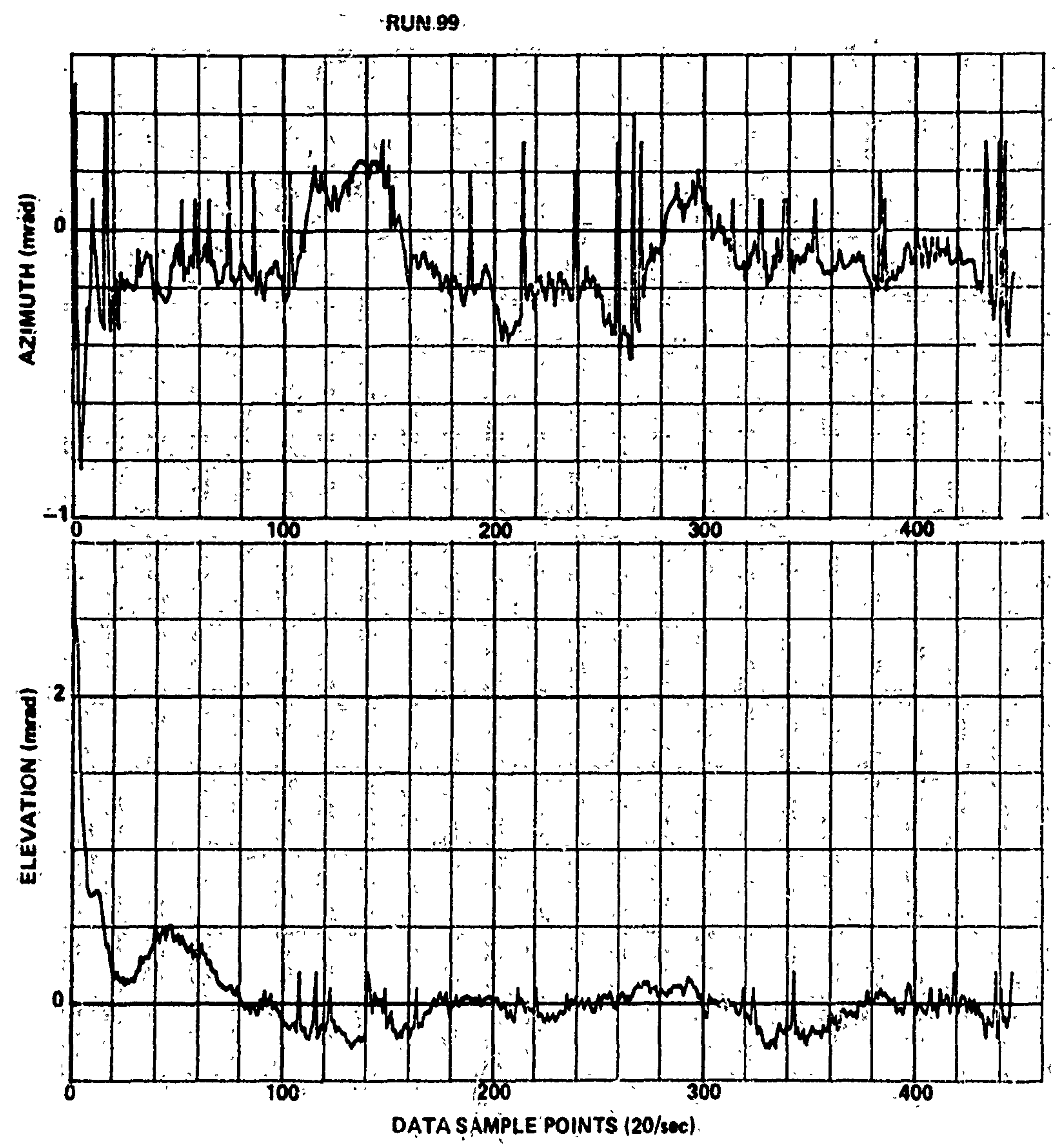
5
0
-5
AZIMUTH (mrad)
0
100
200
300
400
10
0
ELEVATION (mrad)
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)

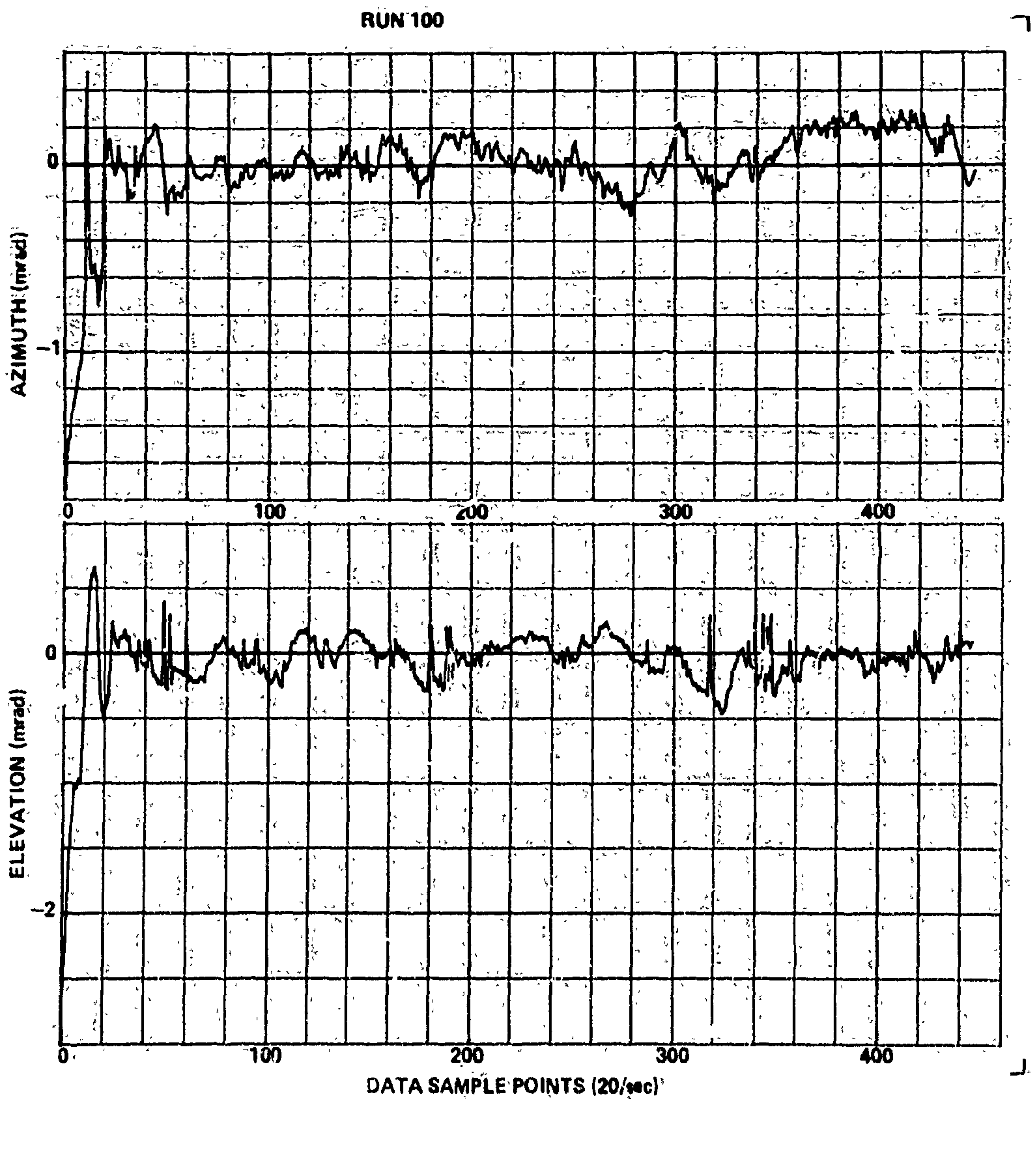

RUN 95
AZIMUTH (mrad)
0
0
100
200
300
400
ELEVATION (mrad)
0
-2
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)



RUN 96
AZIMUTH (mrad)
0
-5
0
100
200
300
400
ELEVATION (mrad)
0
-2
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)

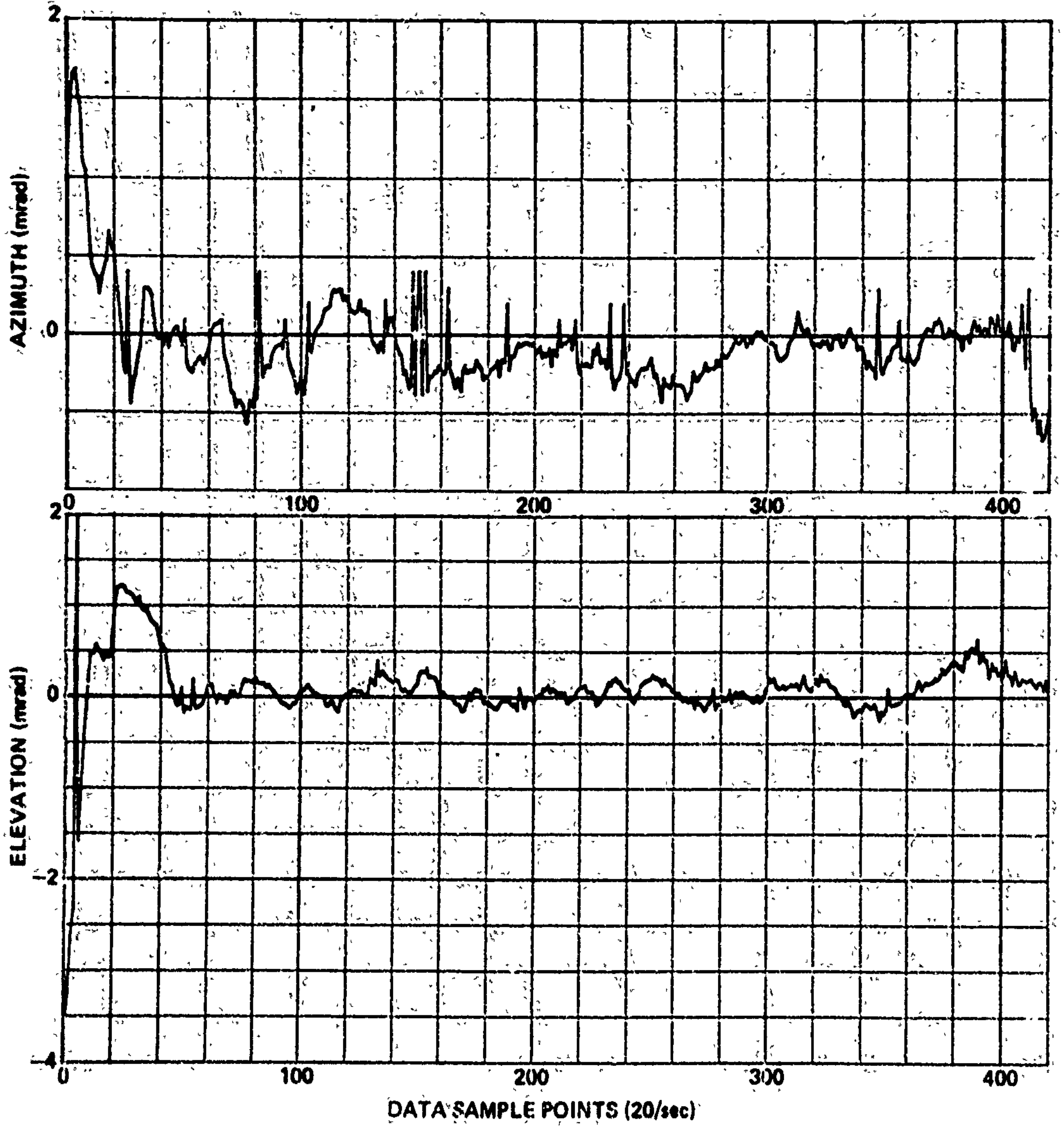

RUN 98
AZIMUTH (mrad)
0
-2
0
200
400
600
ELEVATION (mrad)
10
0
-10
0
200
400
600
DATA SAMPLE POINTS (20/sec)


RUN 99
AZIMUTH (mrad)
0
-1
0
100
200
300
400
ELEVATION (mrad)
2
0
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)

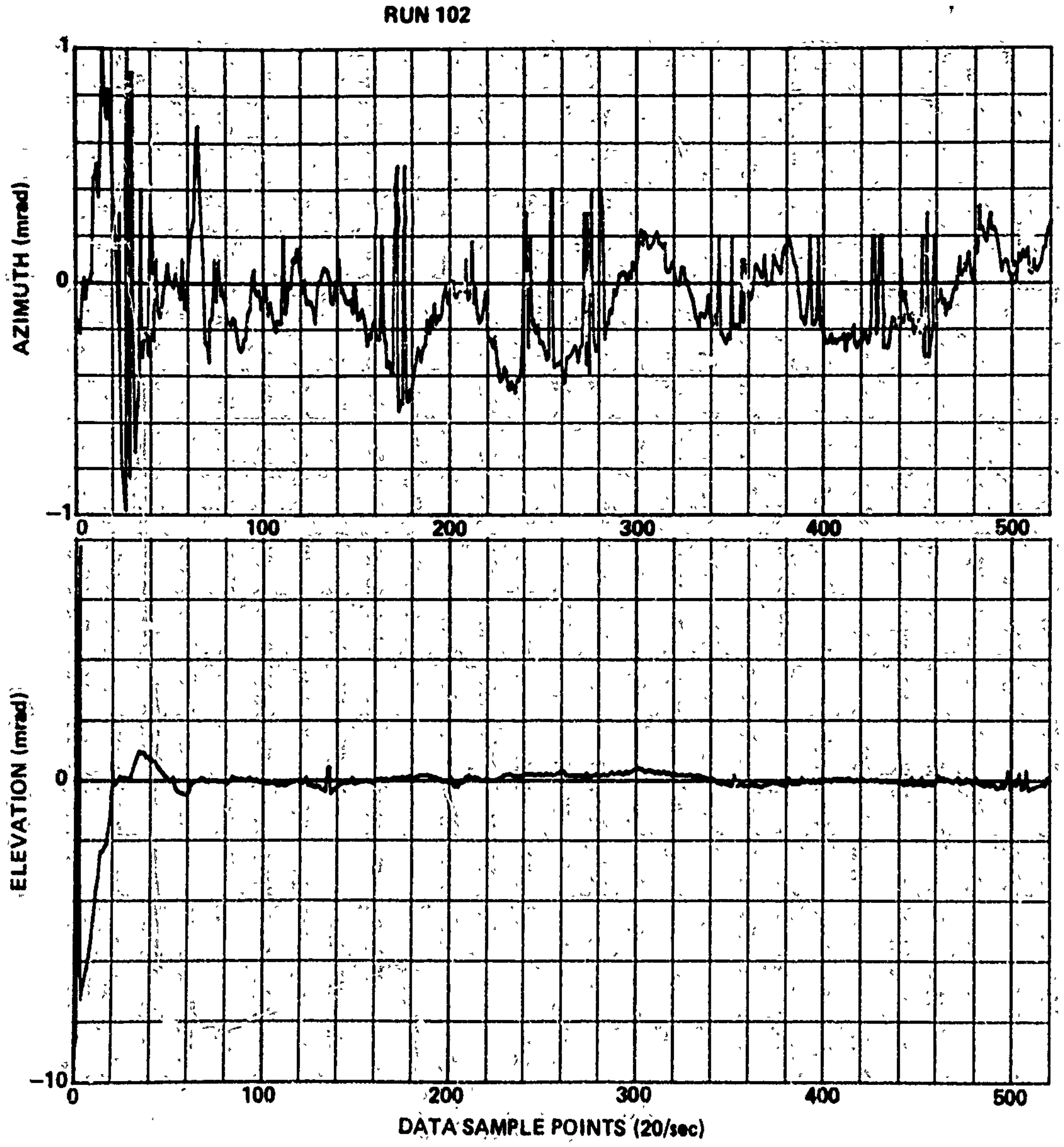


RUN 100
AZIMUTH (mrad)
0
−1
0
100
200
300
400
ELEVATION (mrad)
0
−2
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)

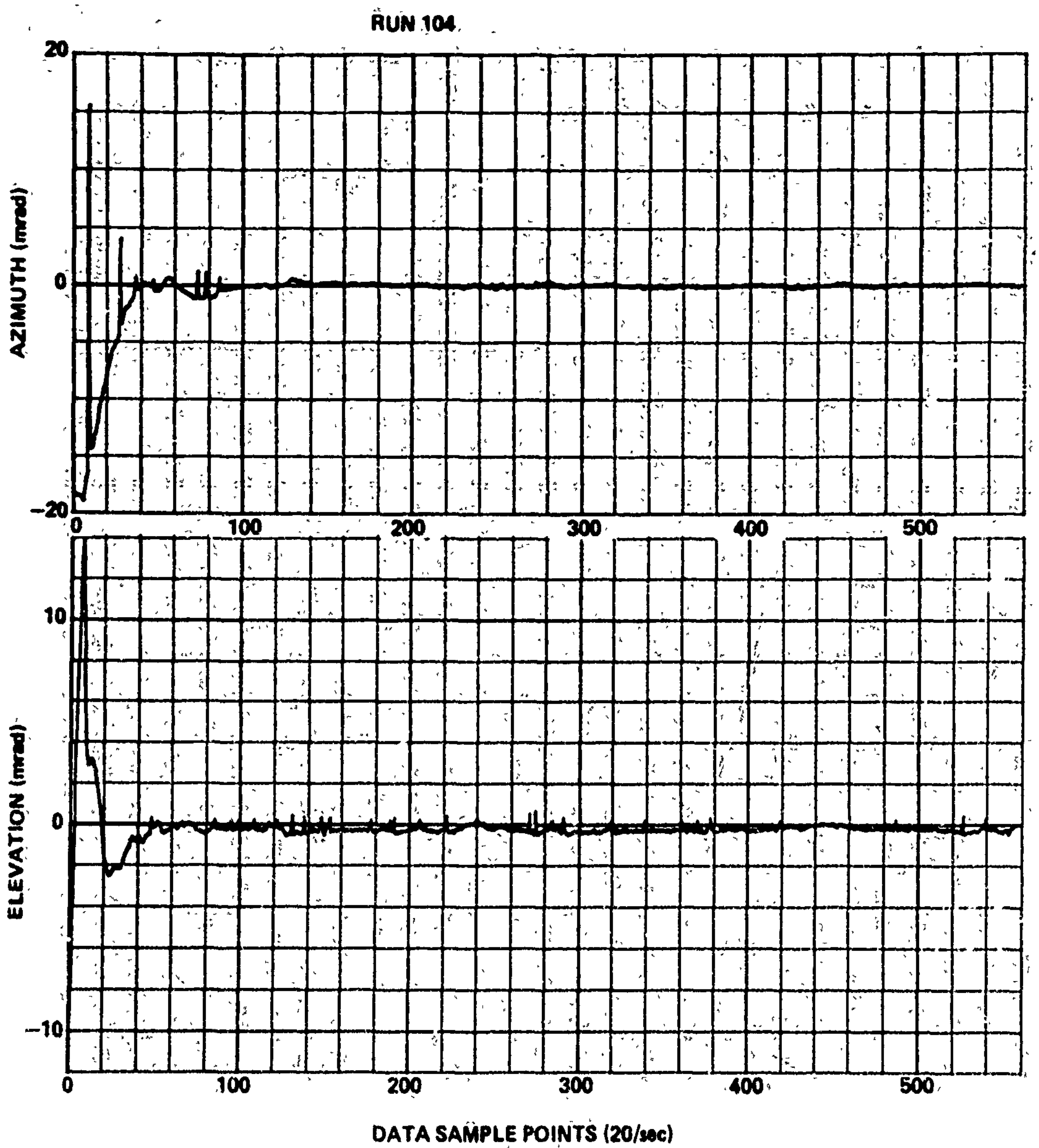
RUN 101



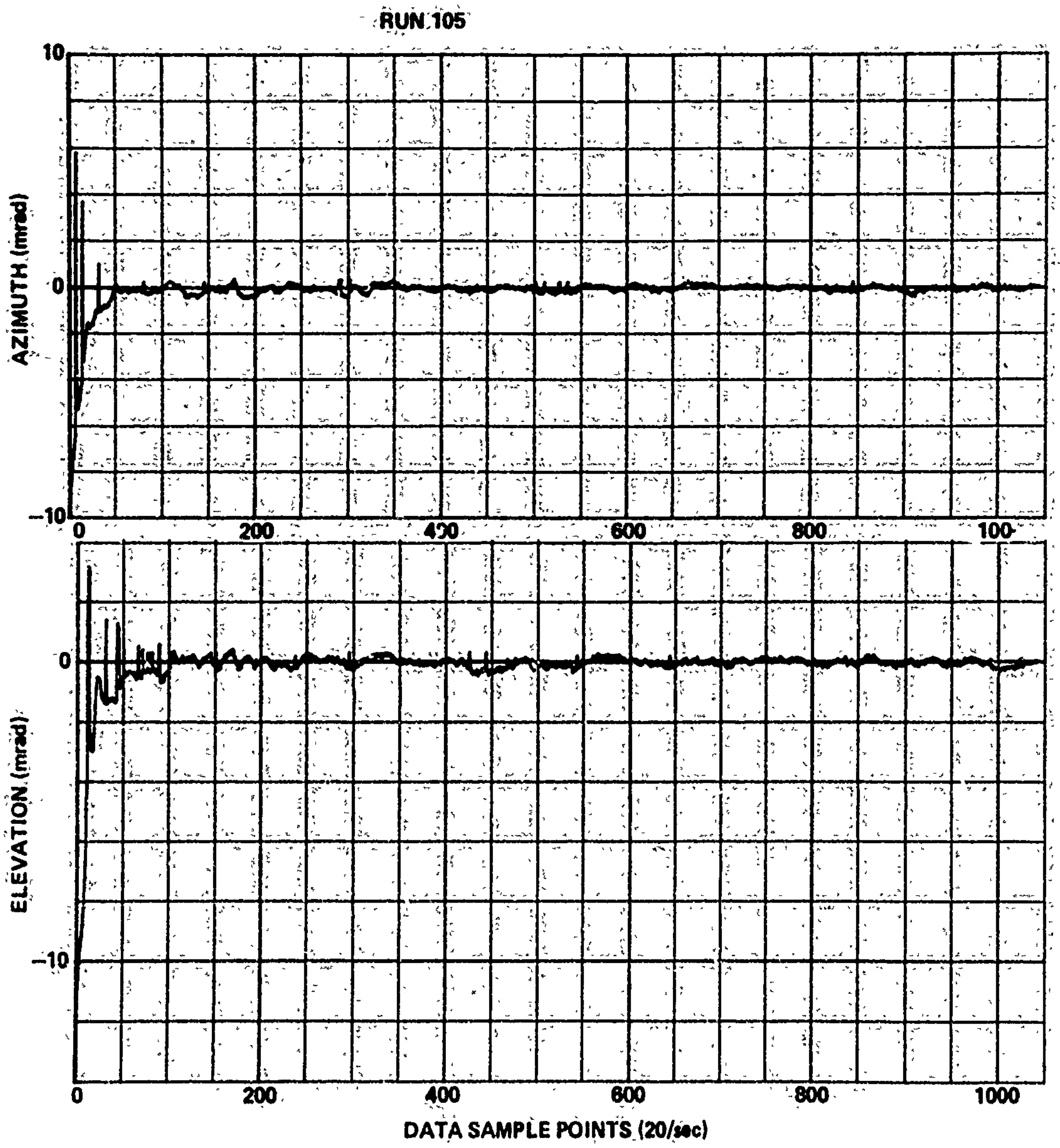
2
0
AZIMUTH (mrad)
0
100
200
300
400
2
0
-2
-4
ELEVATION (mrad)
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)

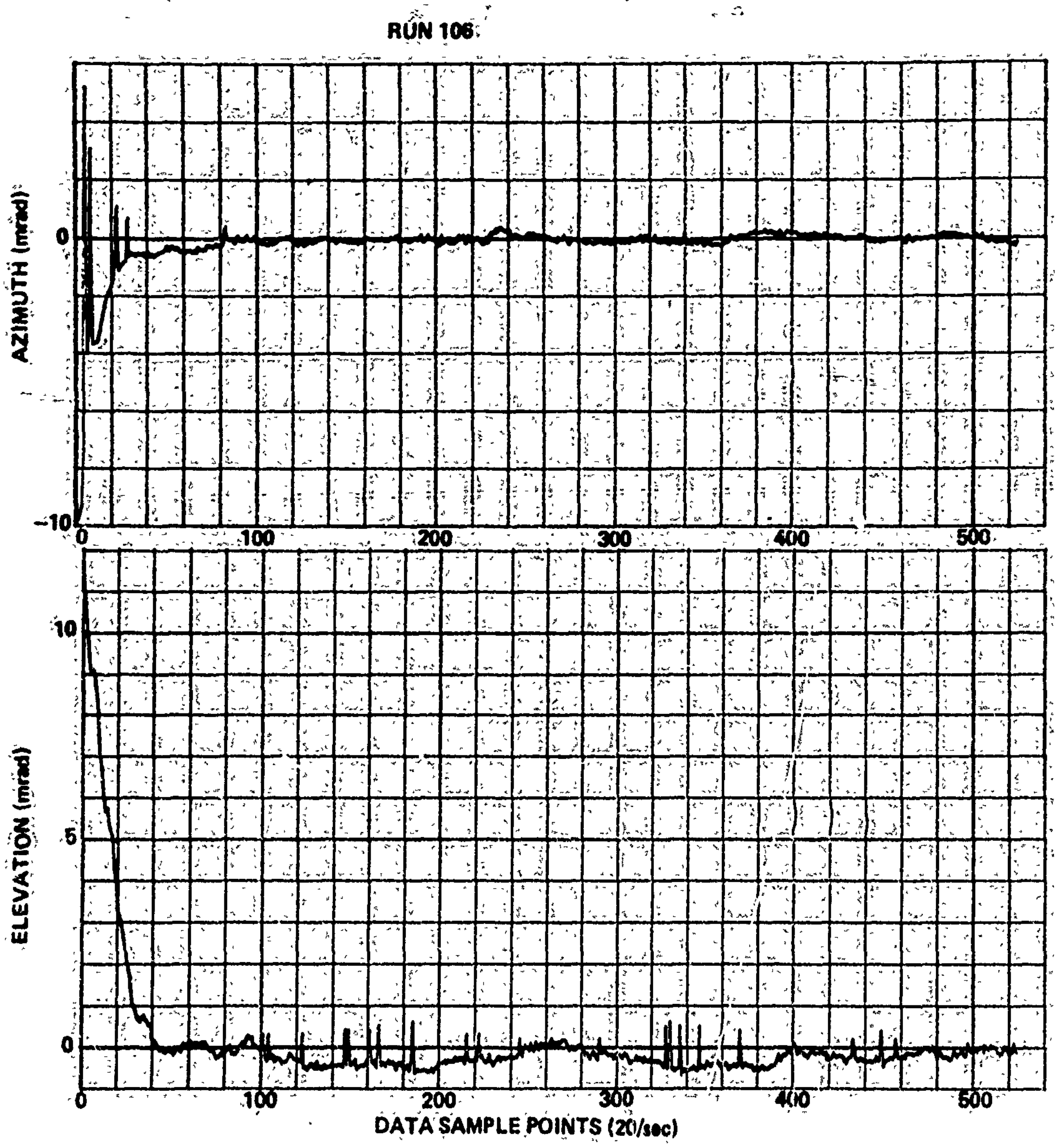


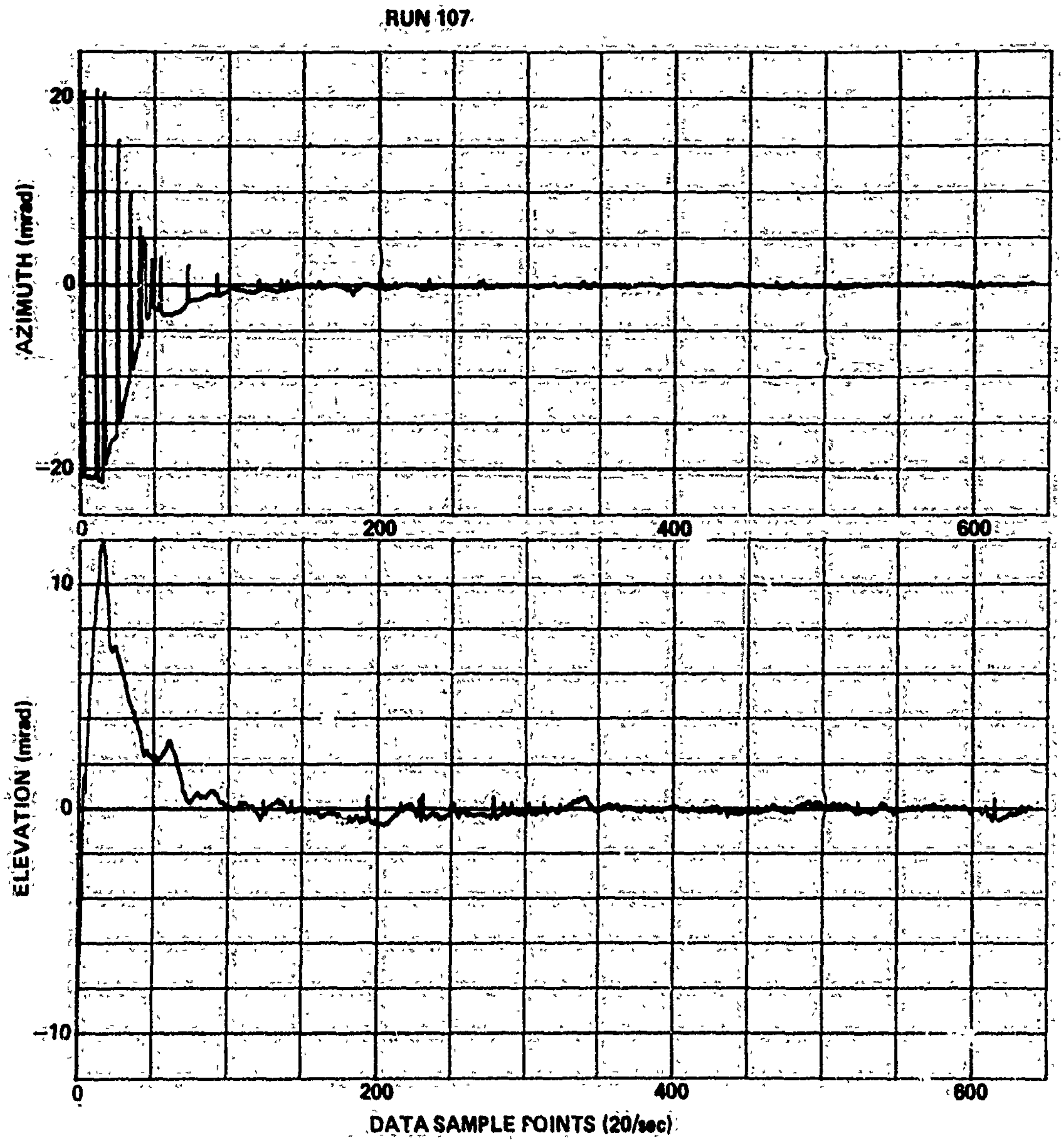
RUN 102
AZIMUTH (mrad)
1
0
−1
0
100
200
300
400
500
ELEVATION (mrad)
0
−10
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)



RUN 104
AZIMUTH (mrad)
20
0
−20
0
100
200
300
400
500
ELEVATION (mrad)
10
0
−10
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

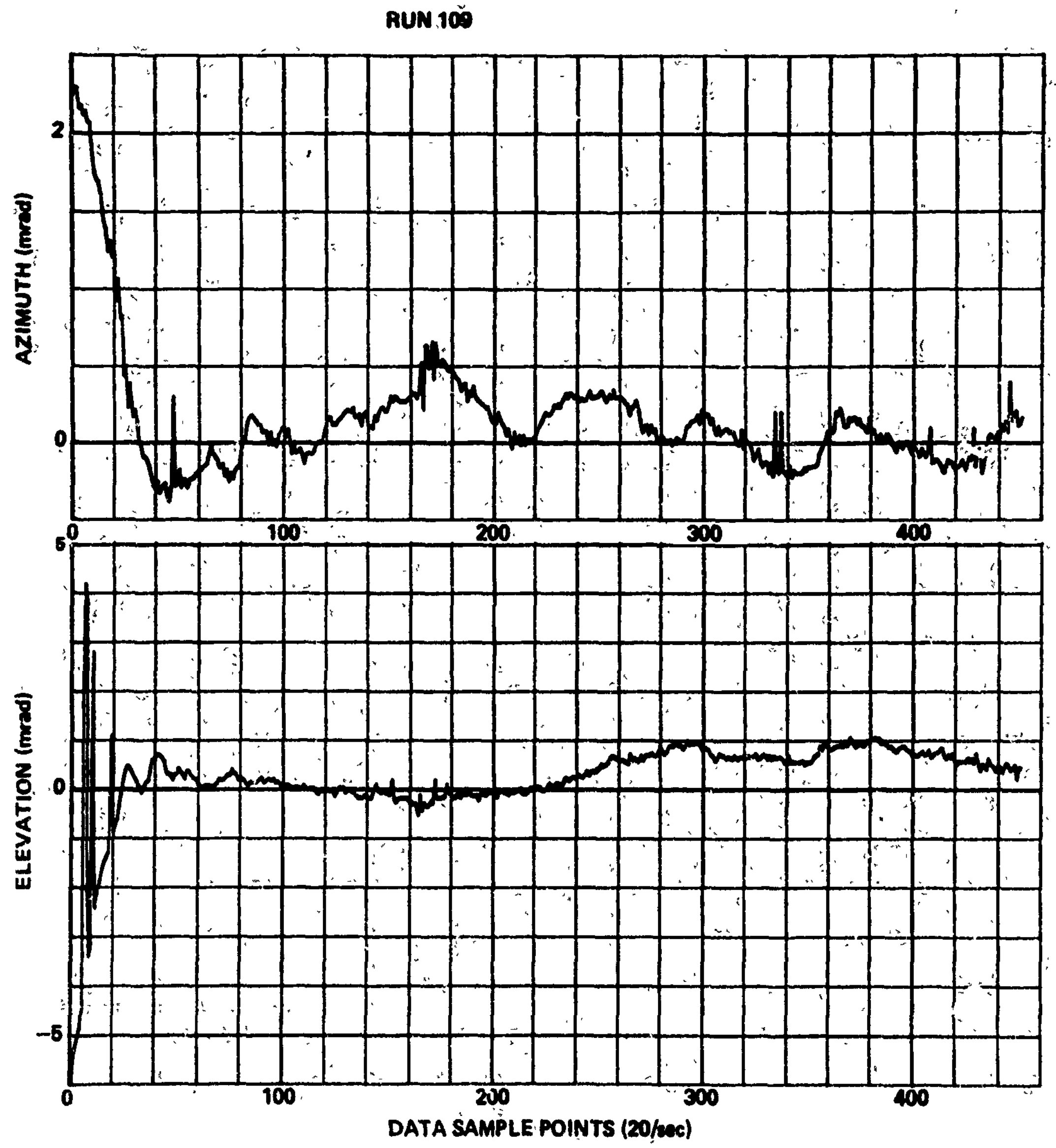

RUN 105
10
0
-10
AZIMUTH (mrad)
0
200
400
600
800
100
0
-10
ELEVATION (mrad)
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)


RUN 106
AZIMUTH (mrad)
0
-10
0
100
200
300
400
500
ELEVATION (mrad)
10
5
0
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

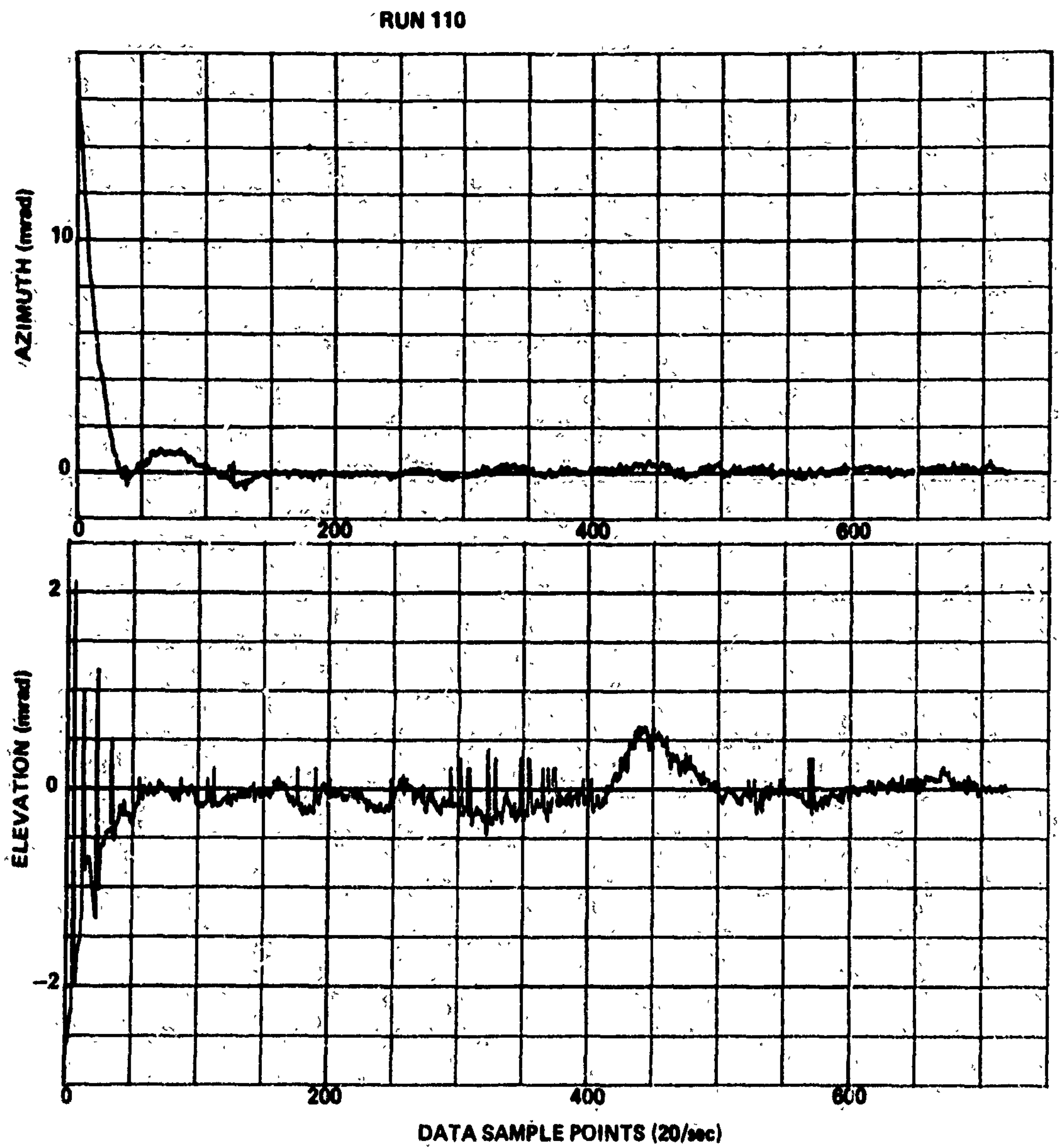


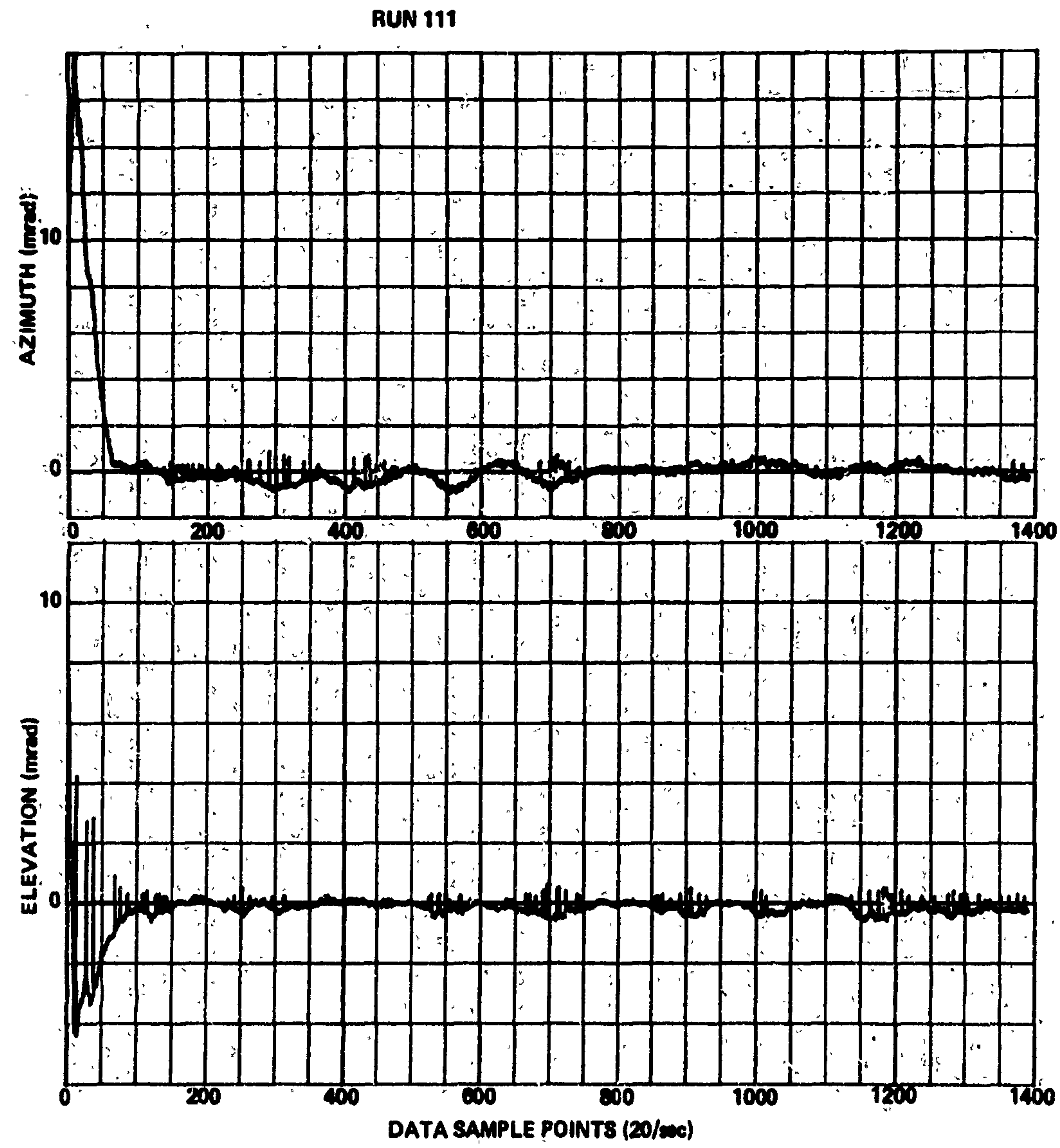
RUN 107
AZIMUTH (mrad)
20
0
-20
0
200
400
600
ELEVATION (mrad)
10
0
-10
0
200
400
600
DATA SAMPLE POINTS (20/sec)

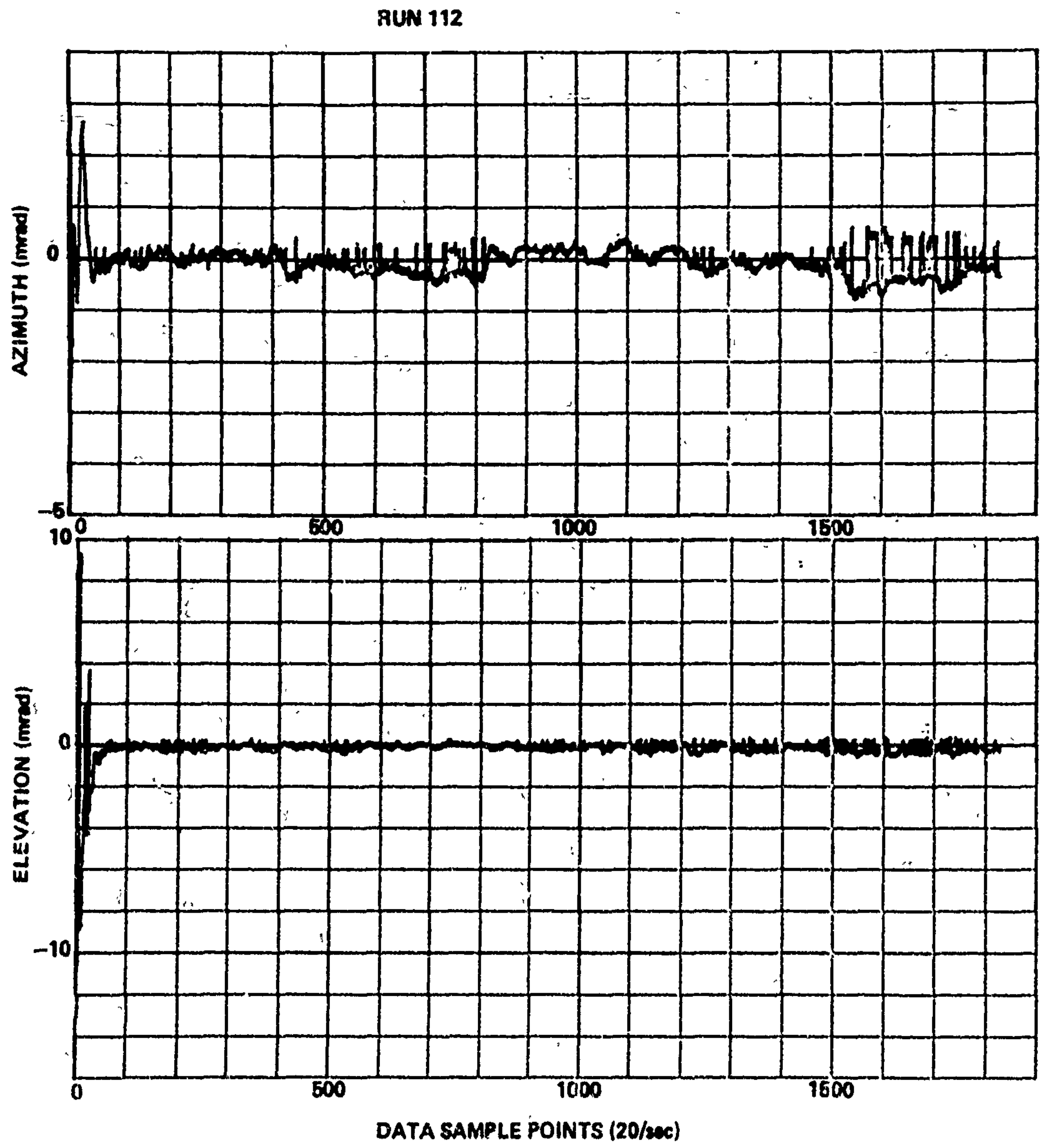

RUN 108
AZIMUTH (mrad)
0
-2
ELEVATION (mrad)
4
2
0
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)



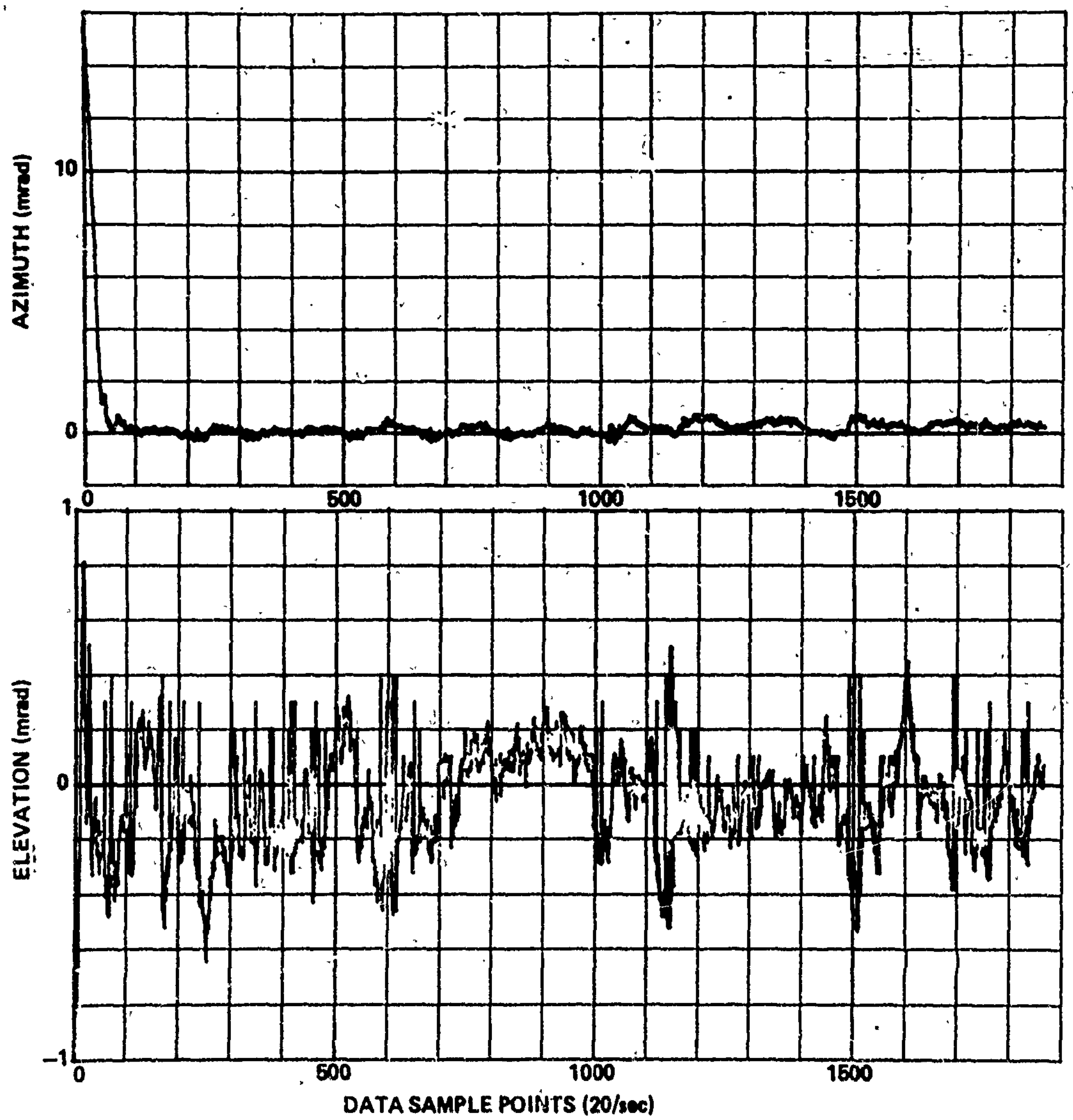
RUN 109
AZIMUTH (mrad)
2
0
0
100
200
300
400
ELEVATION (mrad)
5
0
-5
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)


RUN 110
AZIMUTH (mrad)
10
0
0
200
400
600
ELEVATION (mrad)
2
0
-2
0
200
400
600
DATA SAMPLE POINTS (20/sec)

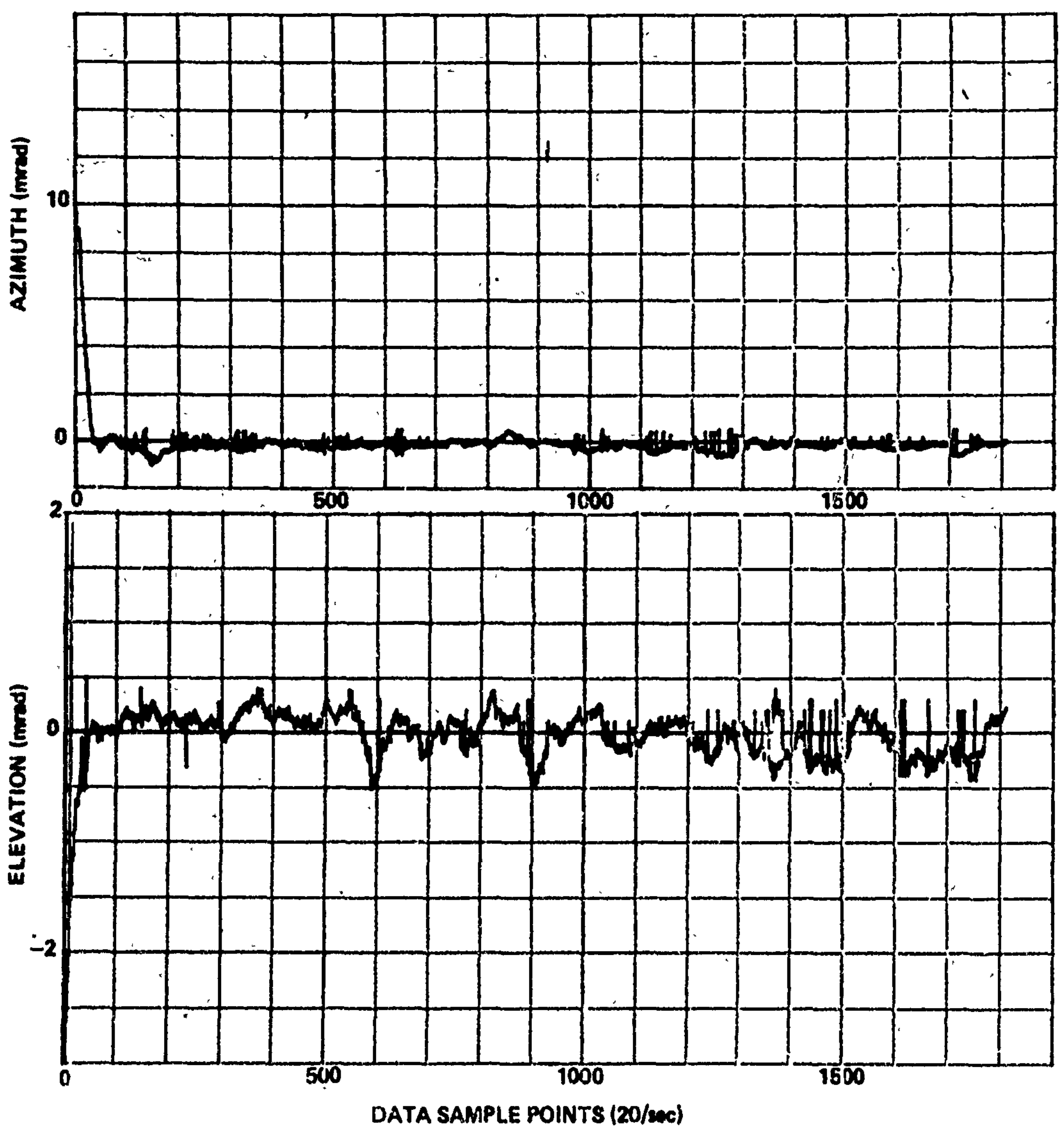

RUN 111
AZIMUTH (mrad)
10
0
0
200
400
600
800
1000
1200
1400
ELEVATION (mrad)
10
0
0
200
400
600
800
1000
1200
1400
DATA SAMPLE POINTS (20/sec)


RUN 112
AZIMUTH (mrad)
0
−5
0
500
1000
1500
ELEVATION (mrad)
10
0
−10
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

RUN 113

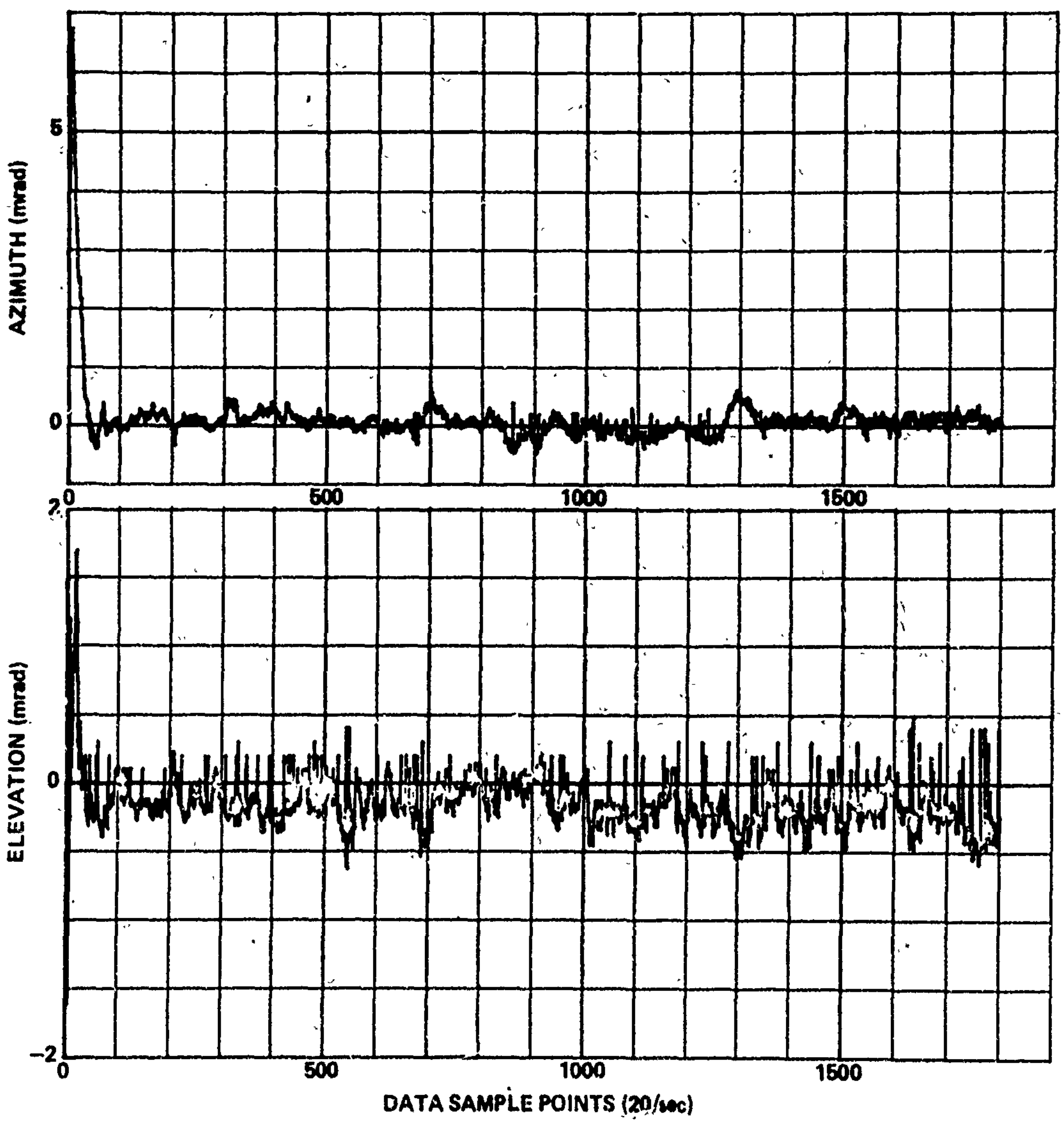

AZIMUTH (mrad)
10
0
0
500
1000
1500
ELEVATION (mrad)
1
0
−1
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

RUN 114



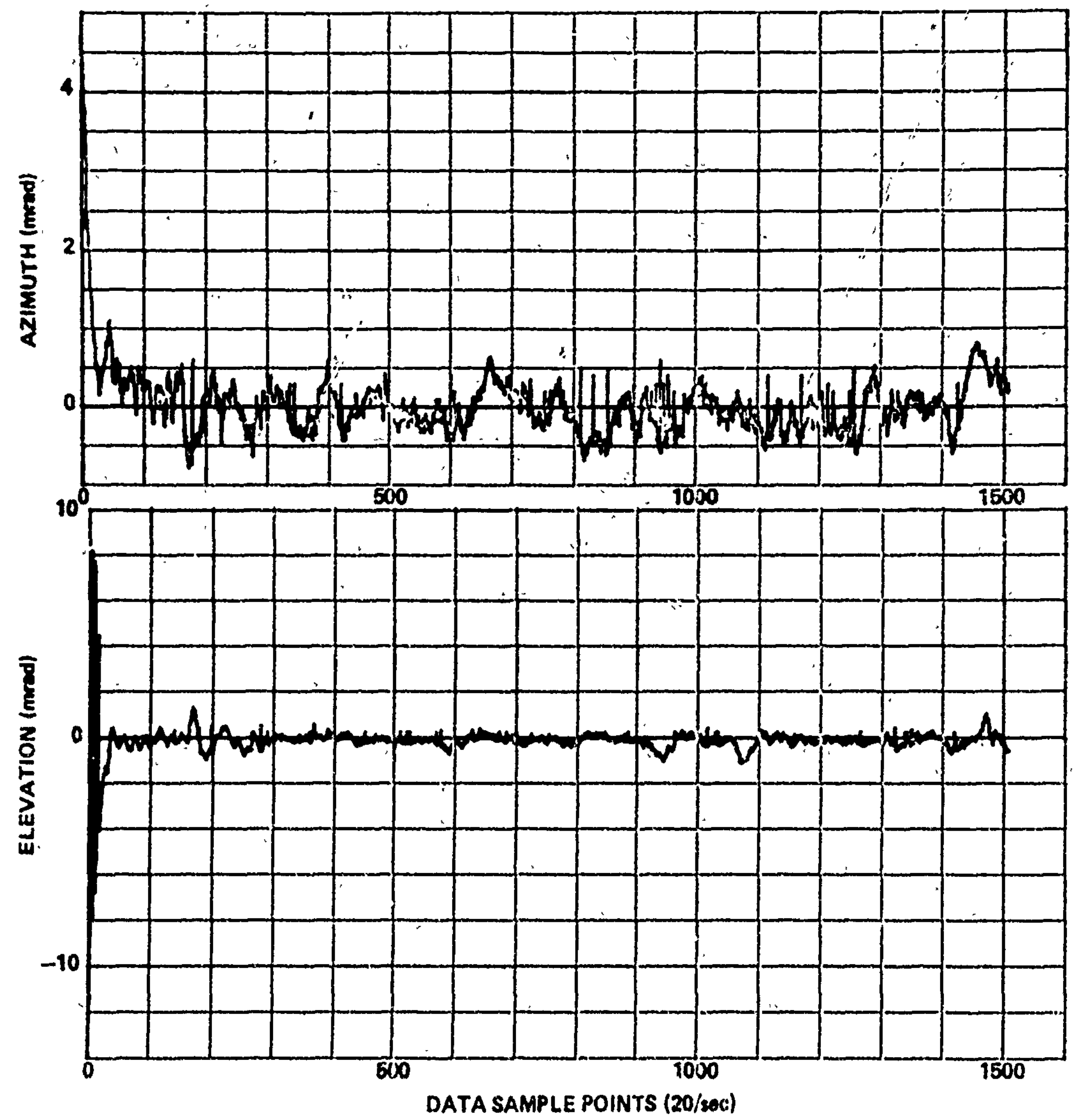
AZIMUTH (mrad)
10
0
0
500
1000
1500
2
ELEVATION (mrad)
0
-2
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

RUN 115



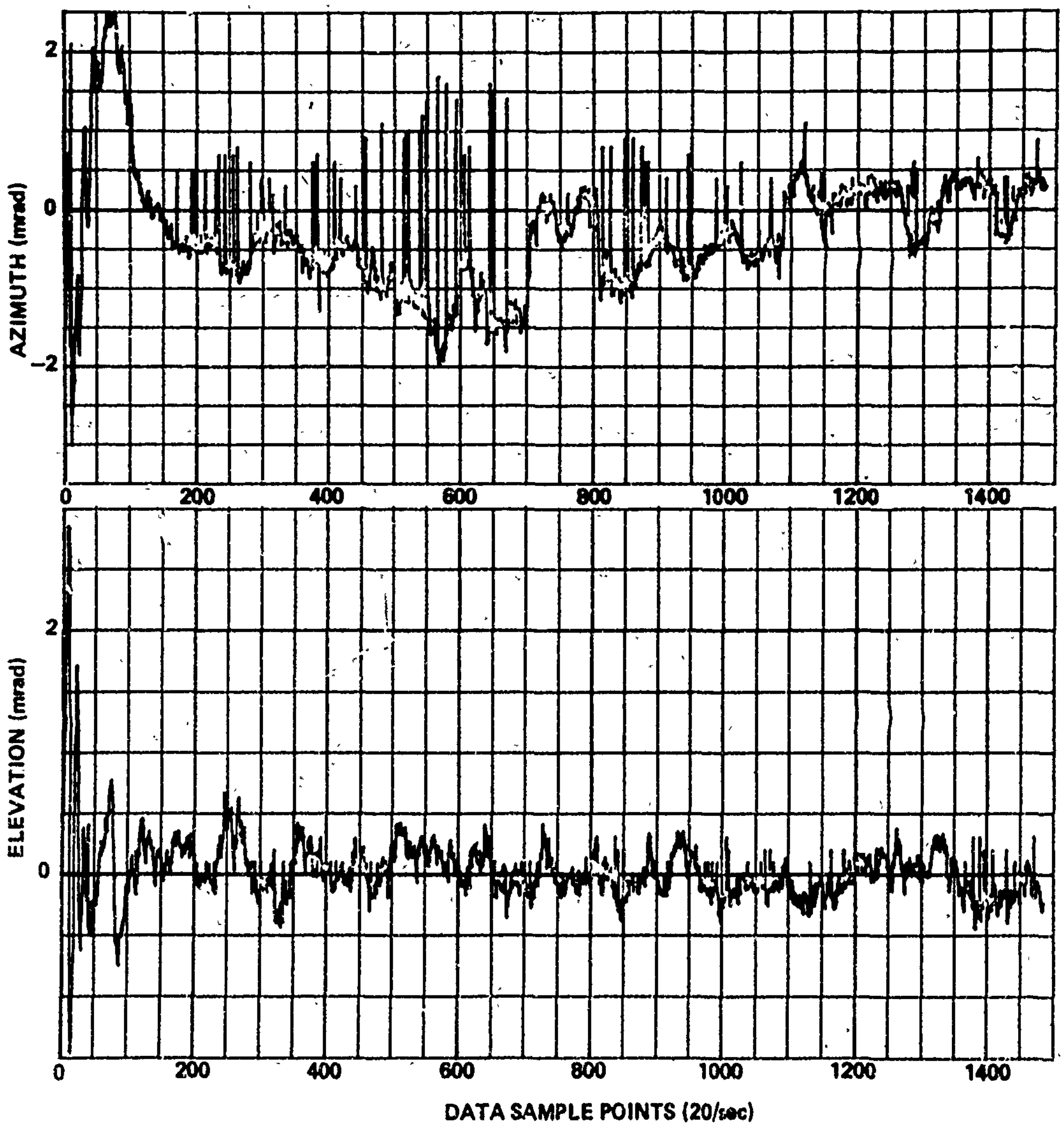
5
0
AZIMUTH (mrad)
0
500
1000
1500
2
0
−2
ELEVATION (mrad)
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

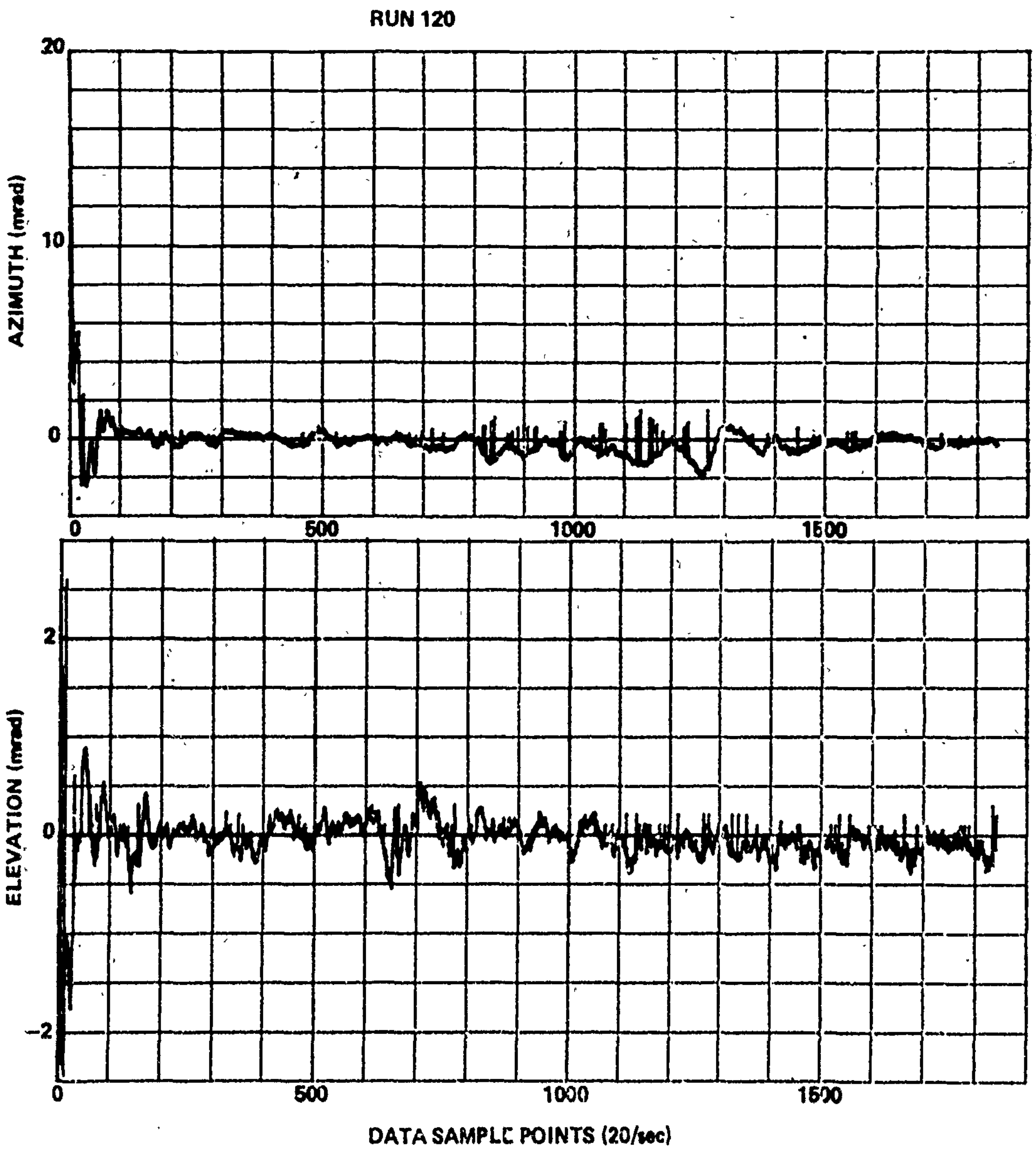
RUN 118

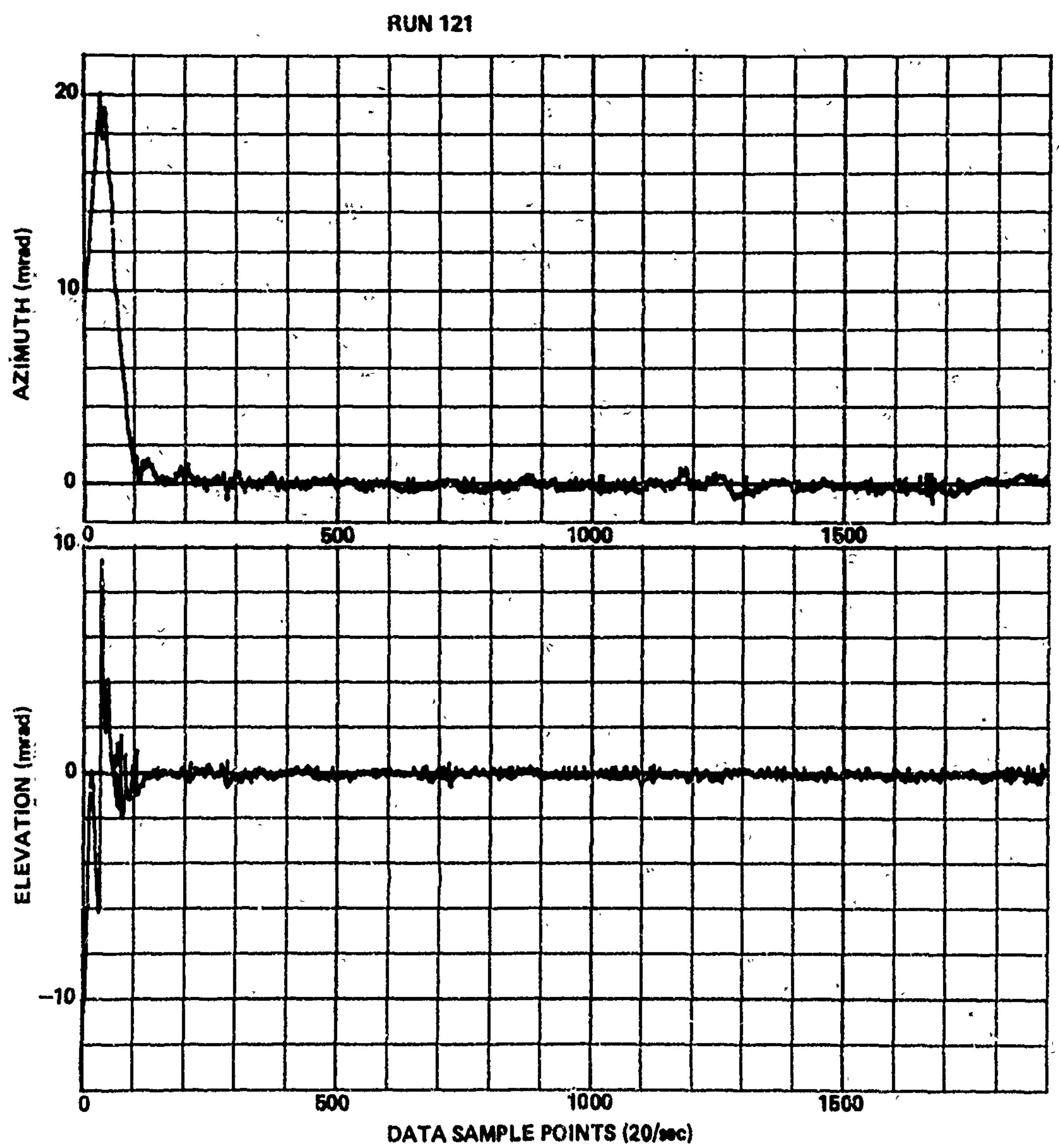


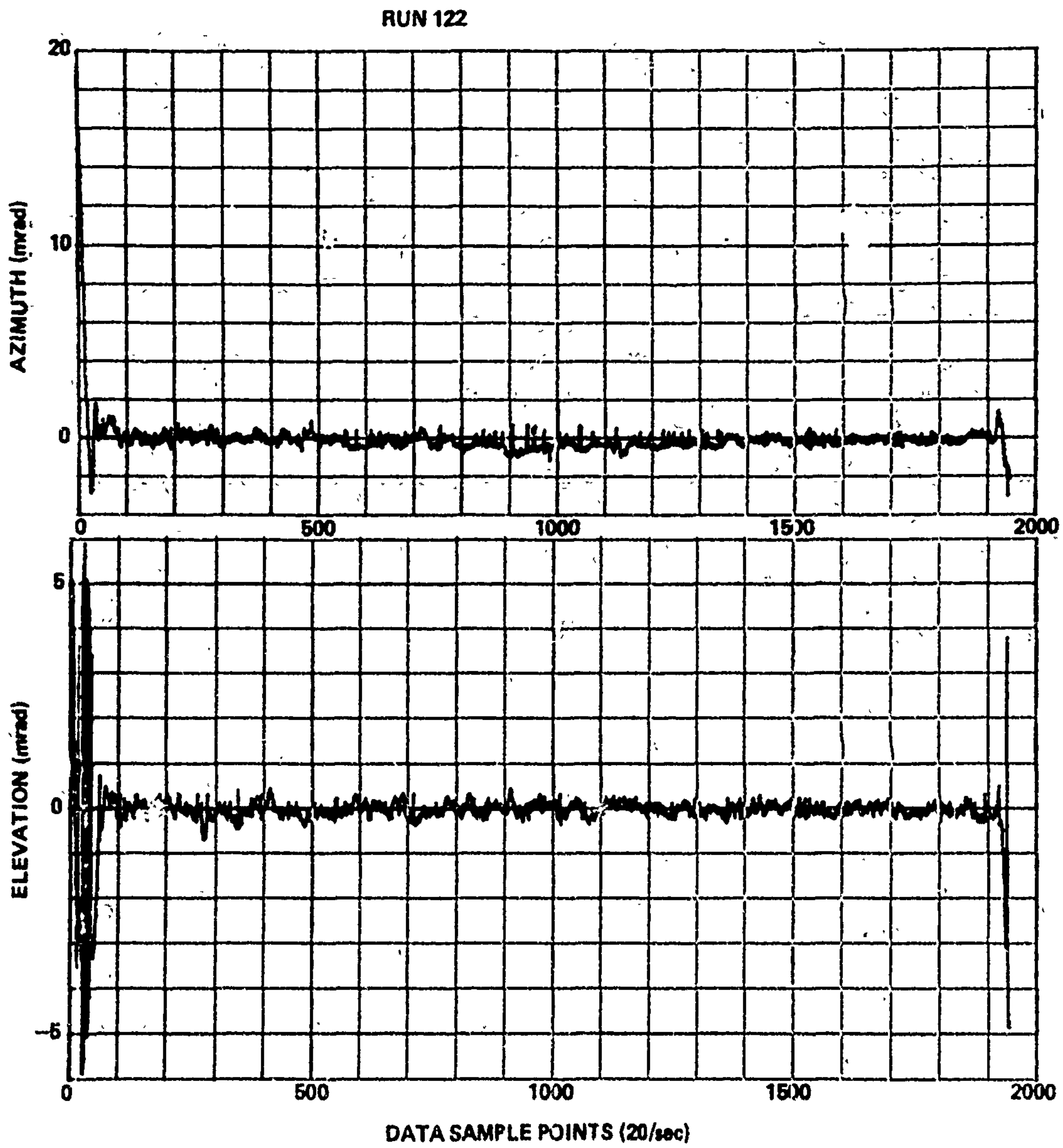
AZIMUTH (mrad)
4
2
0
500
1000
1500
ELEVATION (mrad)
10
0
−10
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

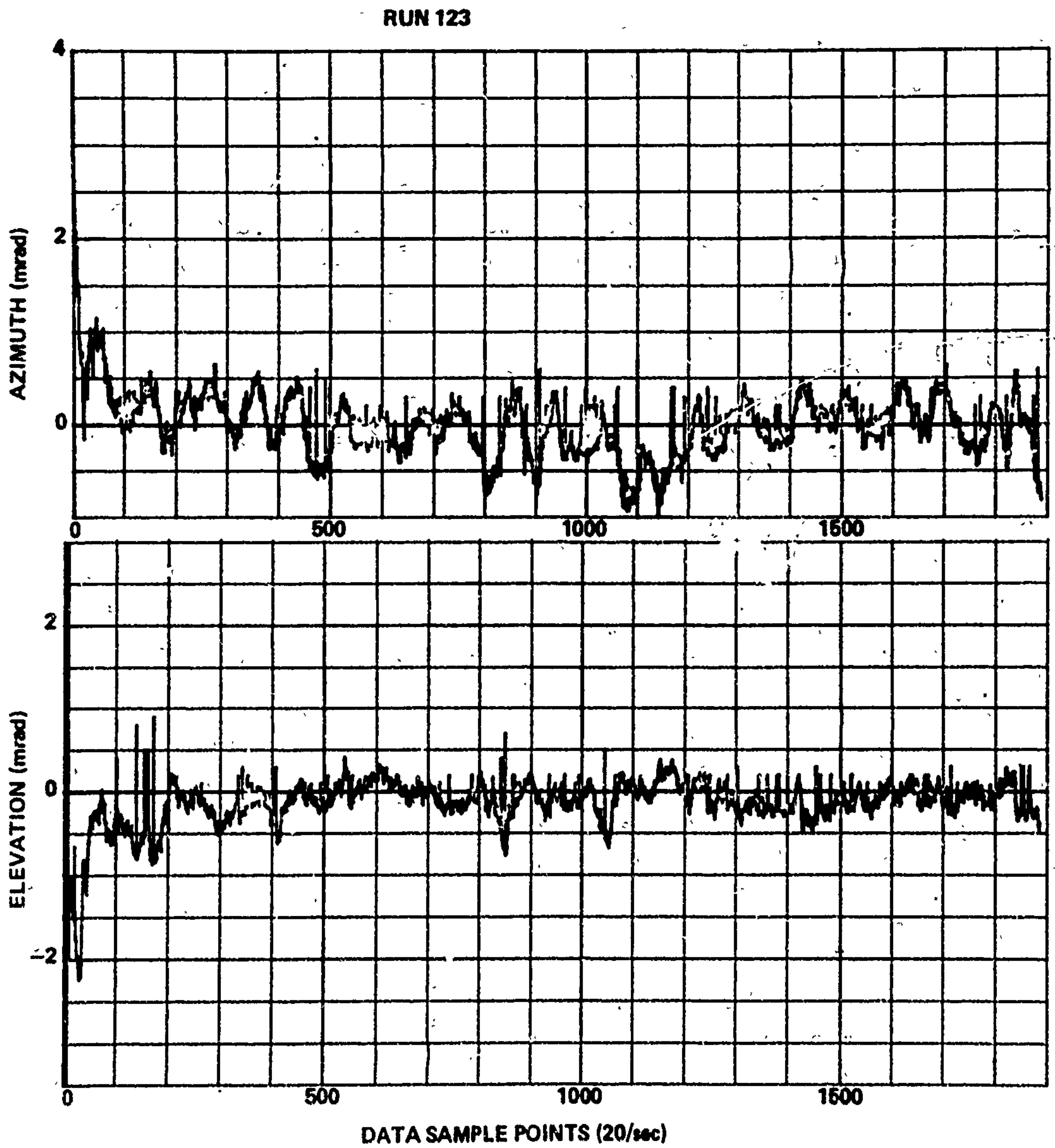
RUN 119


AZIMUTH (mrad)
2
0
-2
0
200
400
600
800
1000
1200
1400
ELEVATION (mrad)
2
0
0
200
400
600
800
1000
1200
1400
DATA SAMPLE POINTS (20/sec)

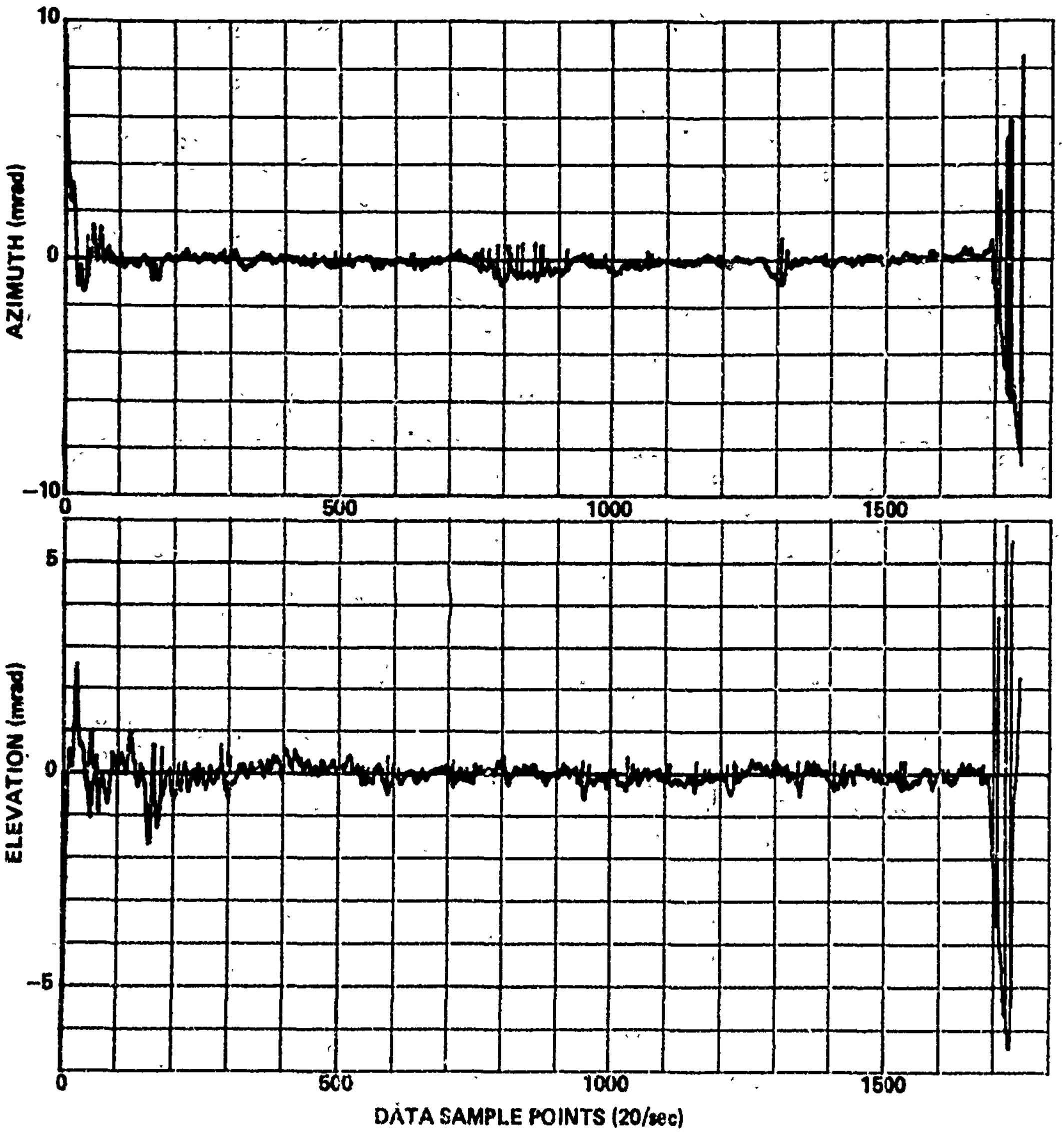

RUN 120
AZIMUTH (mrad)
20
10
0
500
1000
1500
ELEVATION (mrad)
2
0
−2
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)


RUN 121
AZIMUTH (mrad)
20
10
0
0
500
1000
1500
ELEVATION (mrad)
10
0
-10
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

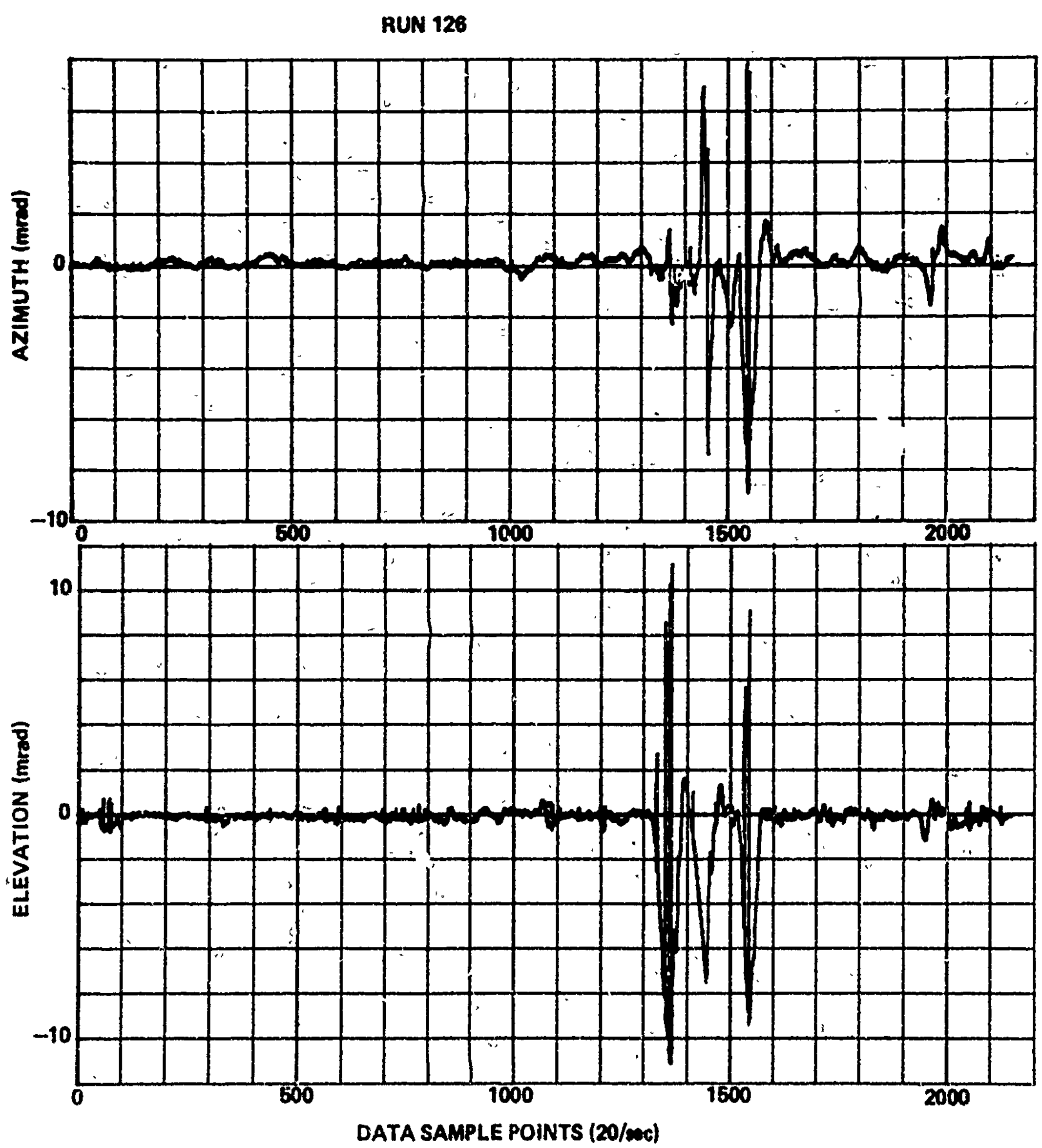

RUN 122
AZIMUTH (mrad)
20
10
0
0
500
1000
1500
2000
ELEVATION (mrad)
5
0
−5
0
500
1000
1500
2000
DATA SAMPLE POINTS (20/sec)

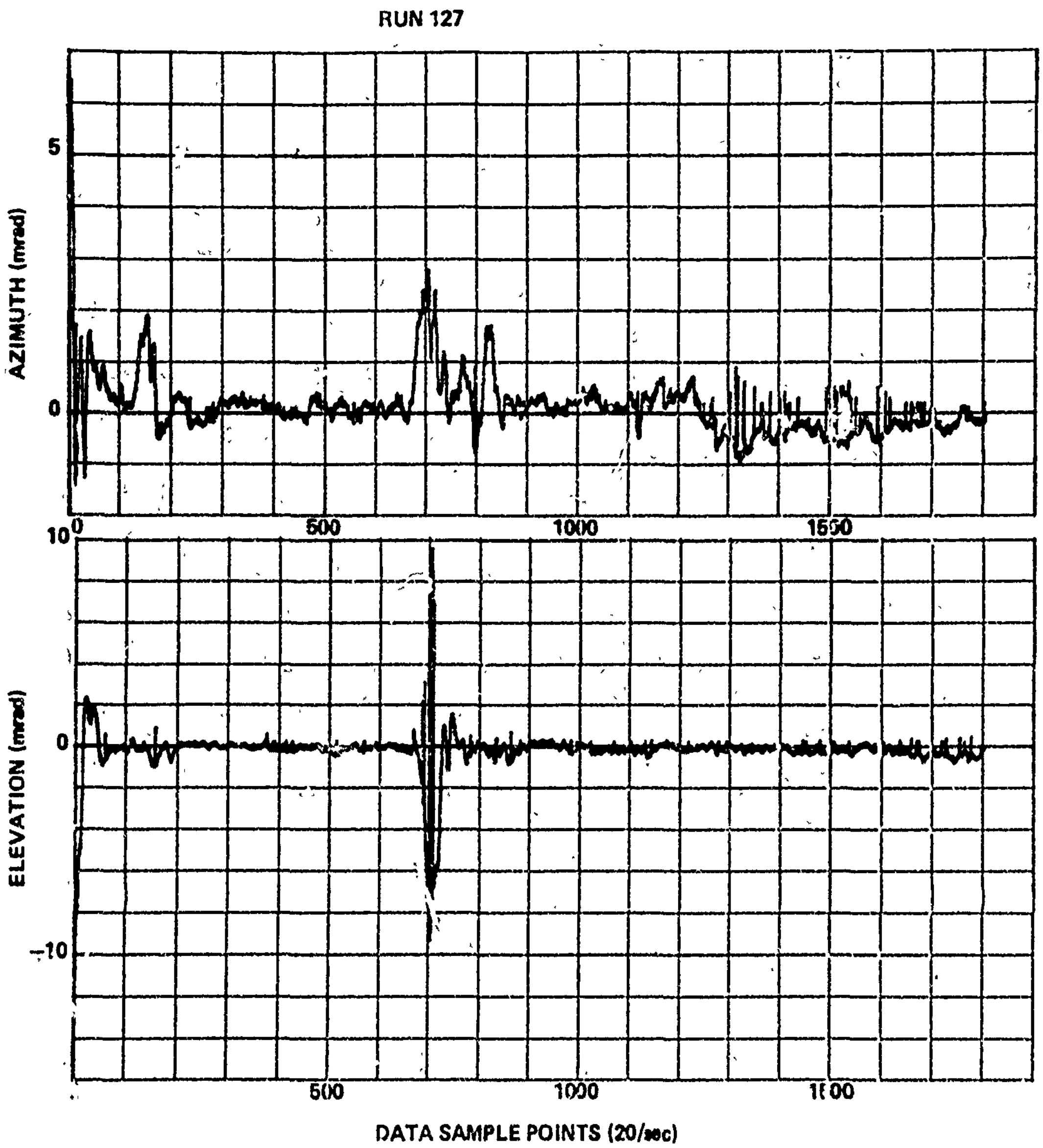

RUN 123
AZIMUTH (mrad)
4
2
0
0
500
1000
1500
ELEVATION (mrad)
2
0
-2
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

RUN 124



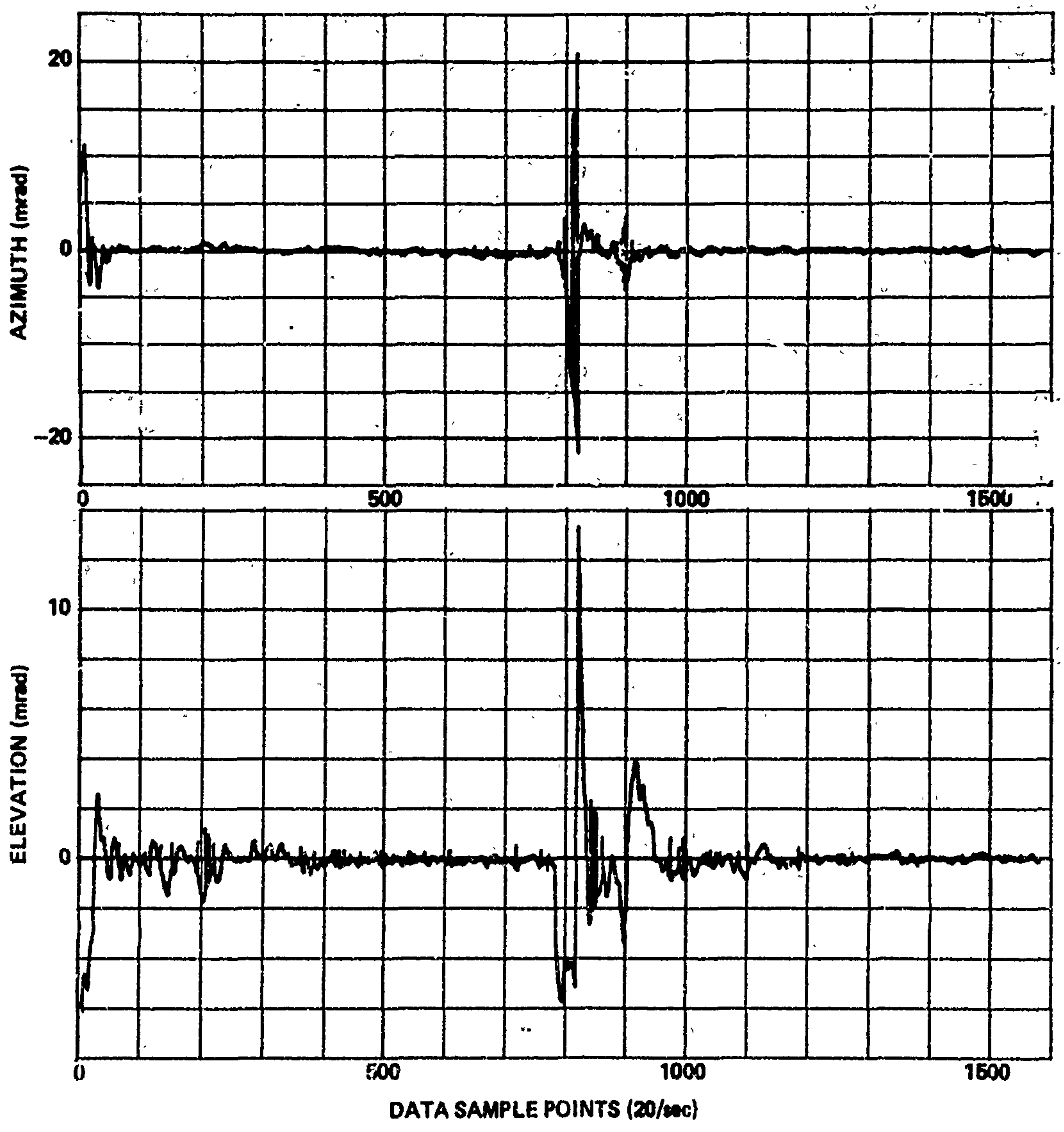
AZIMUTH (mrad)
10
0
-10
0
500
1000
1500
ELEVATION (mrad)
5
0
-5
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)


RUN 126
AZIMUTH (mrad)
0
-10
0
500
1000
1500
2000
ELEVATION (mrad)
10
0
-10
0
500
1000
1500
2000
DATA SAMPLE POINTS (20/sec)



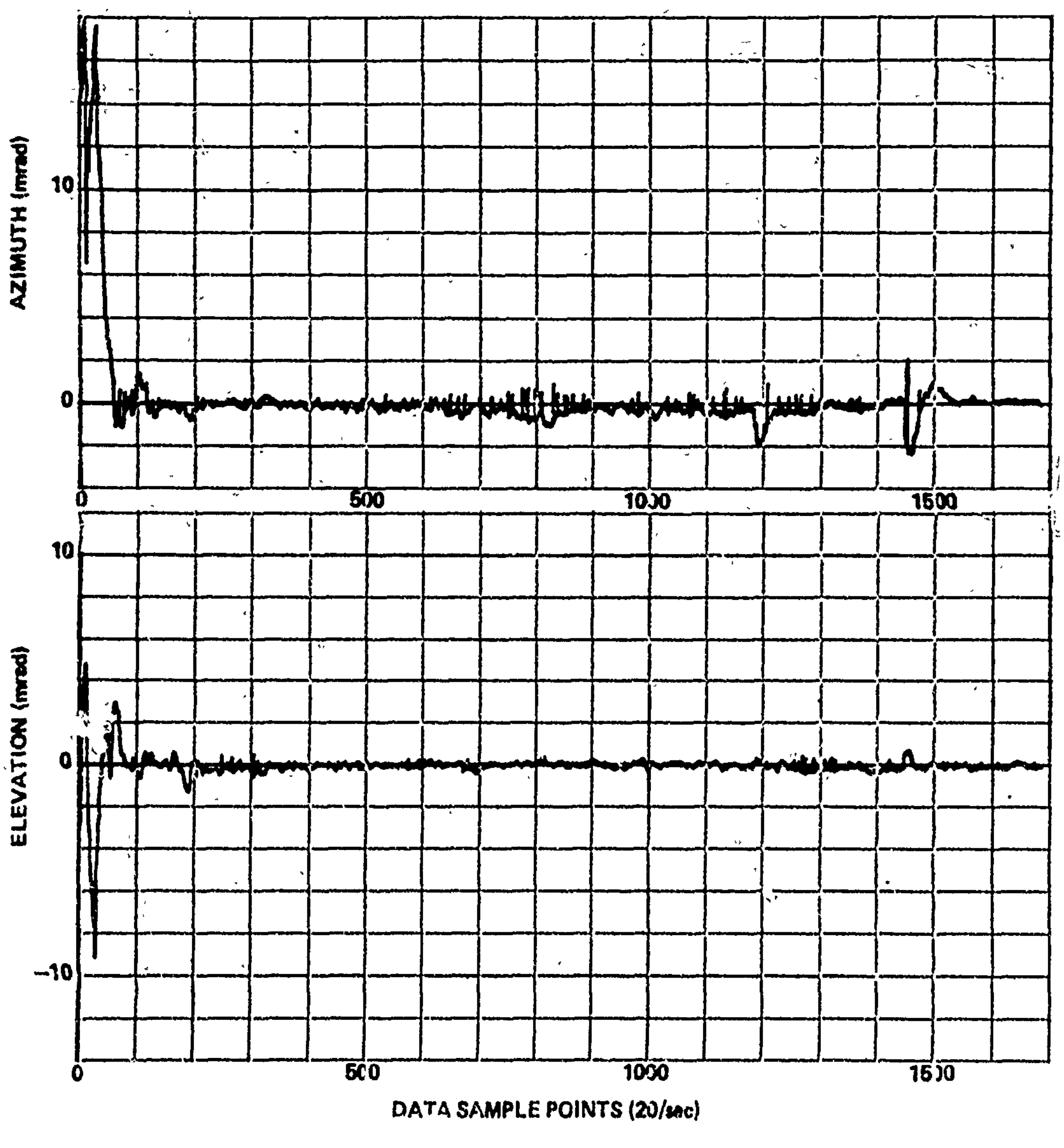
RUN 127
5
0
AZIMUTH (mrad)
500
1000
1500
10
0
-10
ELEVATION (mrad)
500
1000
1500
DATA SAMPLE POINTS (20/sec)

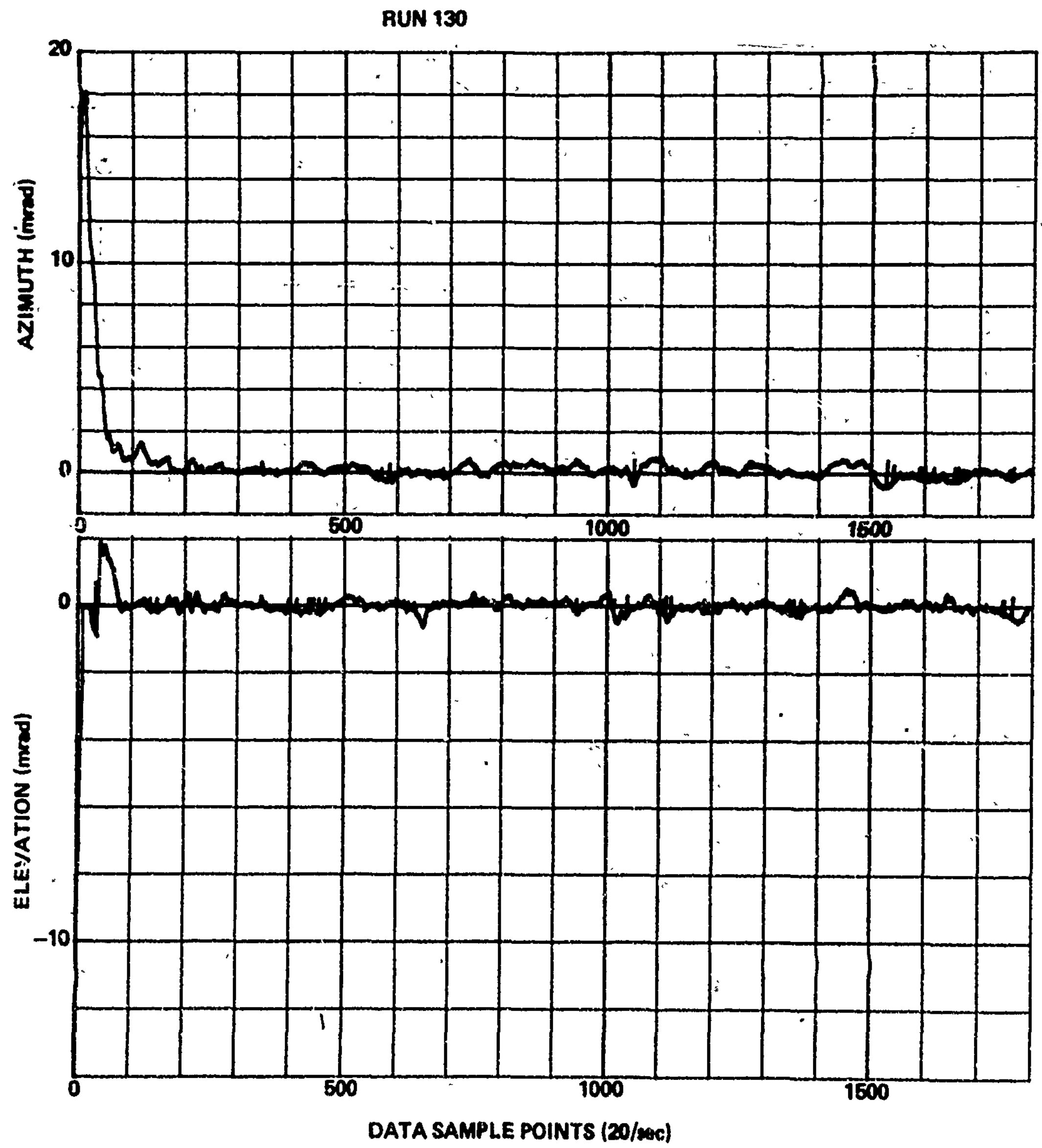
RUN 128

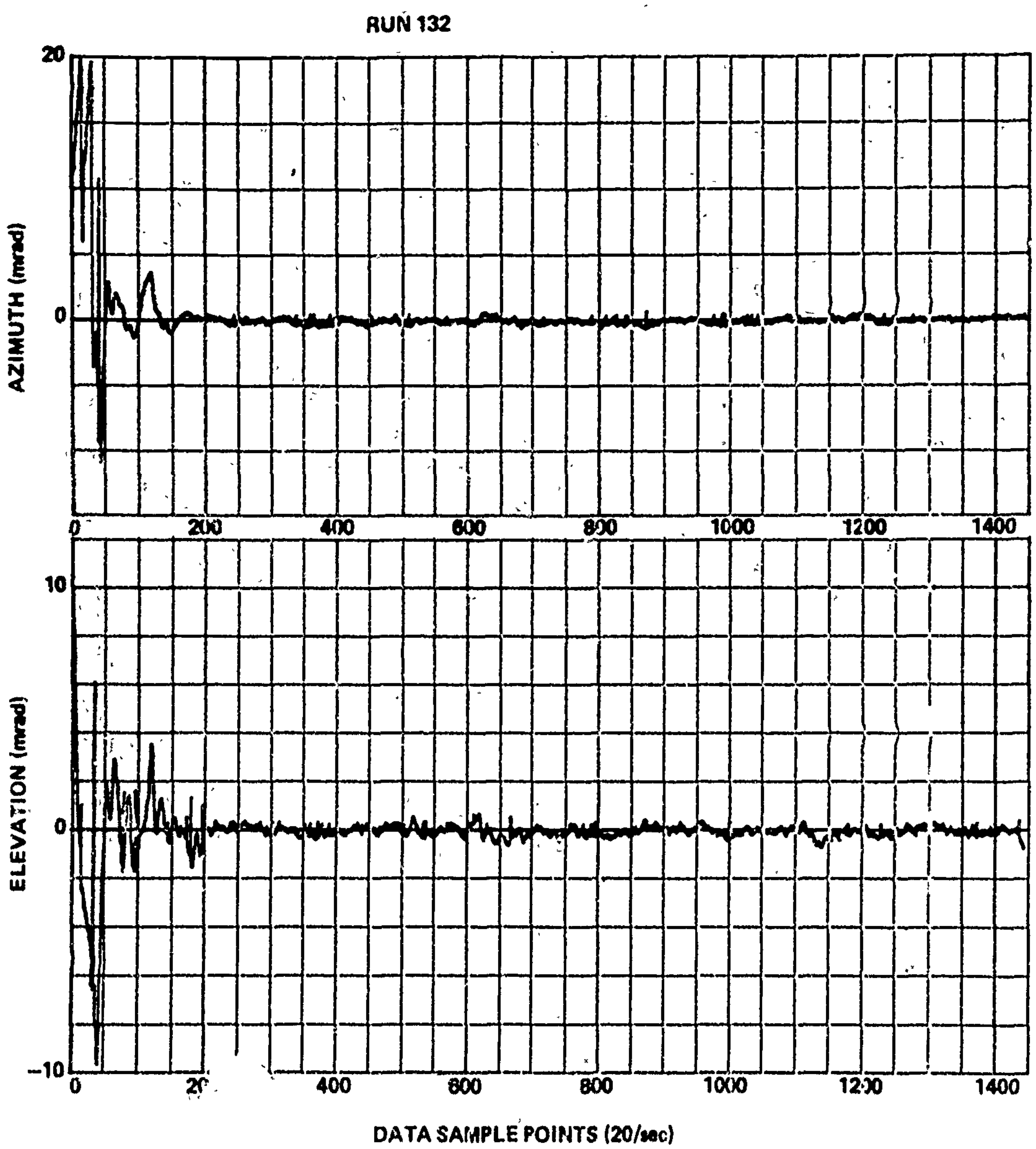


20
0
−20
AZIMUTH (mrad)
0
500
1000
1500
10
0
ELEVATION (mrad)
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

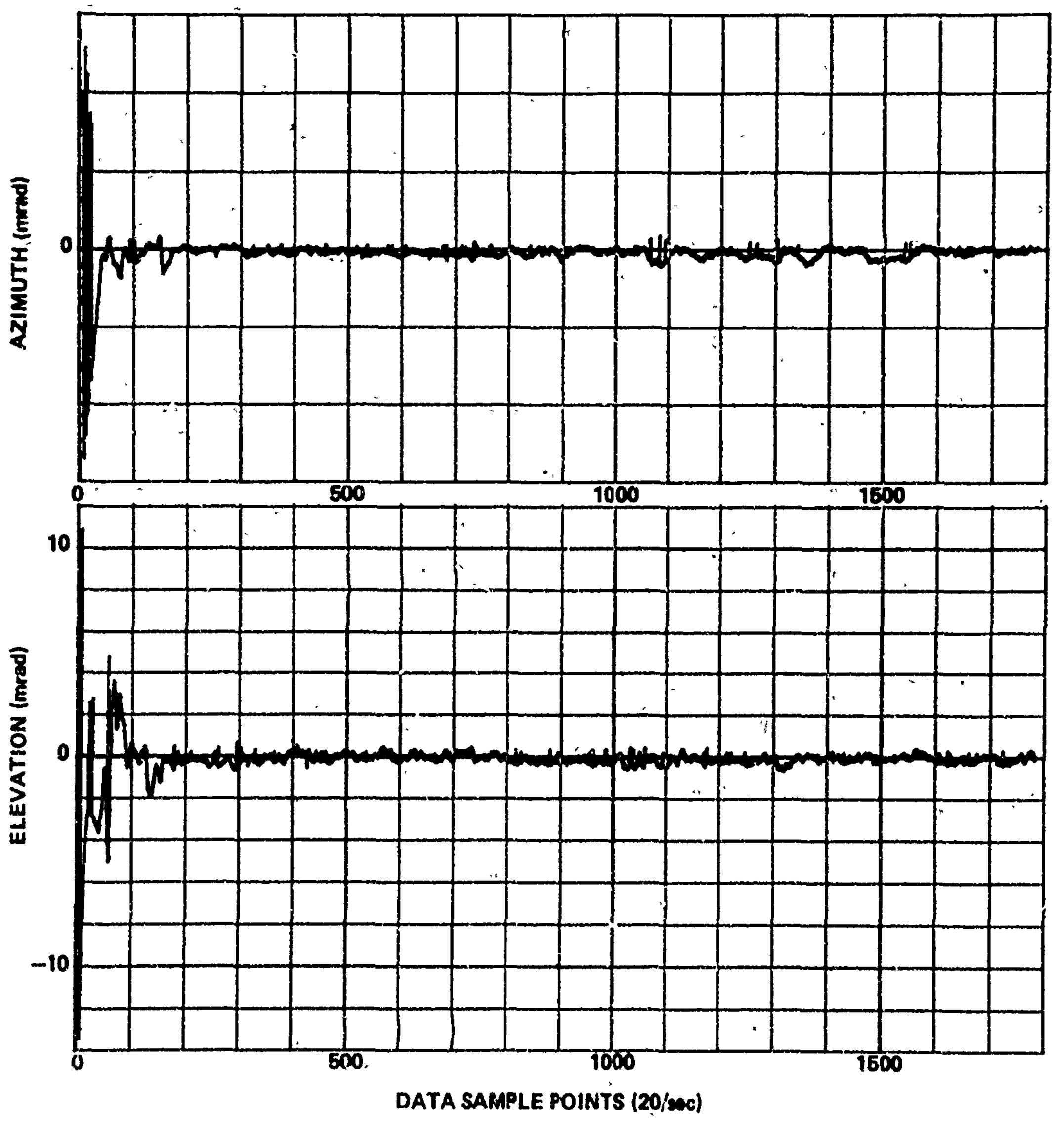
RUN 129


AZIMUTH (mrad)
10
0
0
500
1000
1500
10
ELEVATION (mrad)
0
−10
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

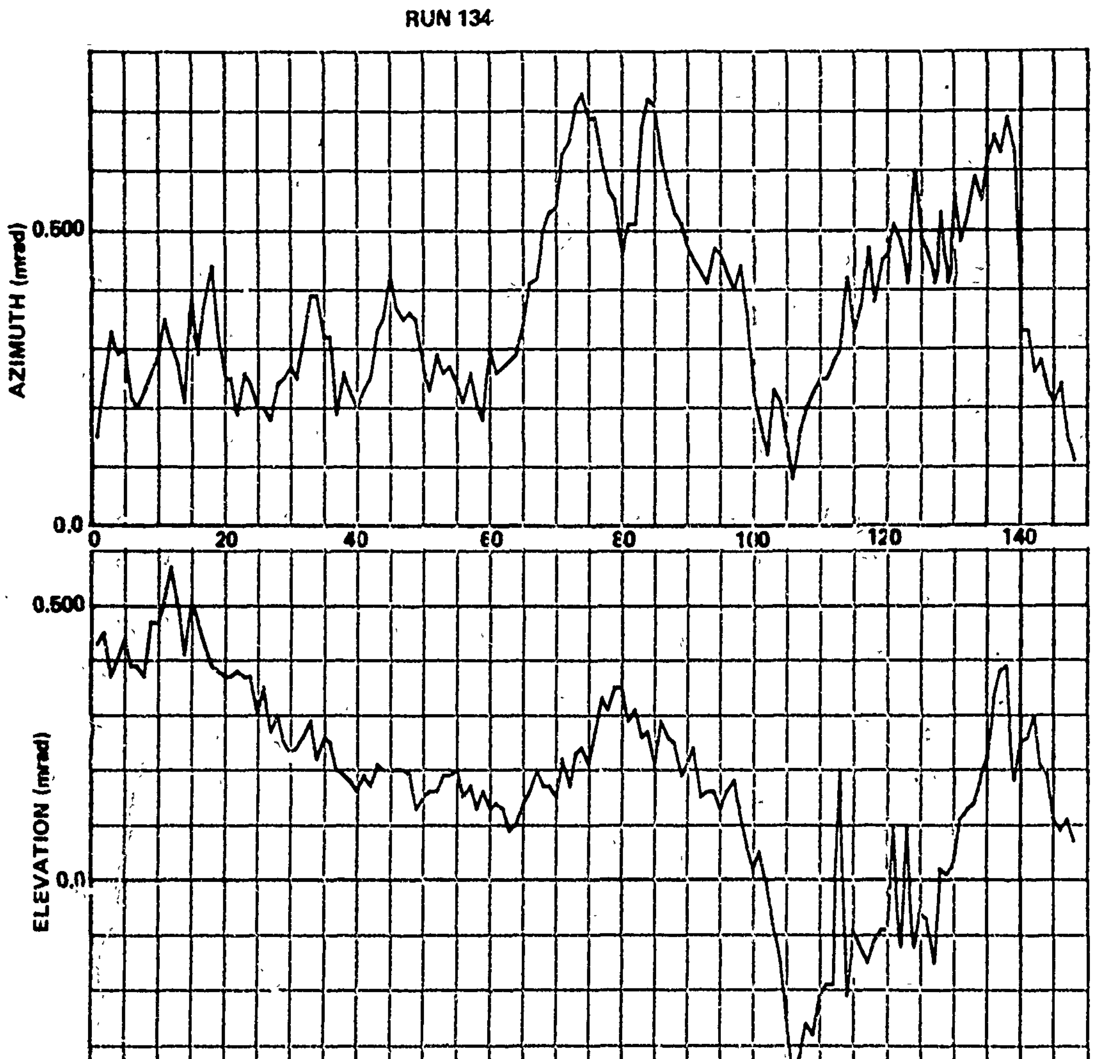

RUN 130
20
10
0
AZIMUTH (mrad)
0
500
1000
1500
0
-10
ELEVATION (mrad)
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

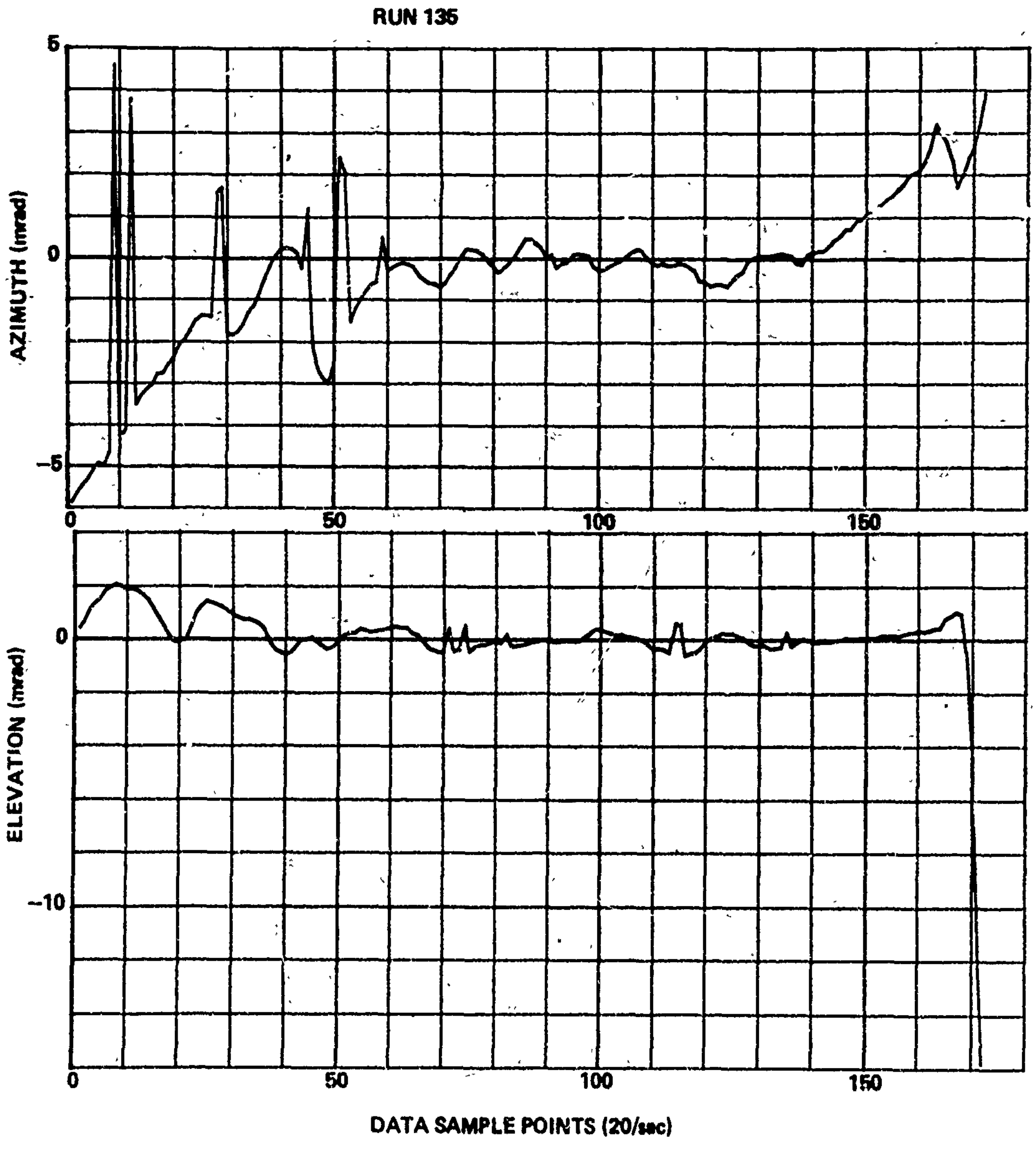

RUN 132
AZIMUTH (mrad)
ELEVATION (mrad)
DATA SAMPLE POINTS (20/sec)

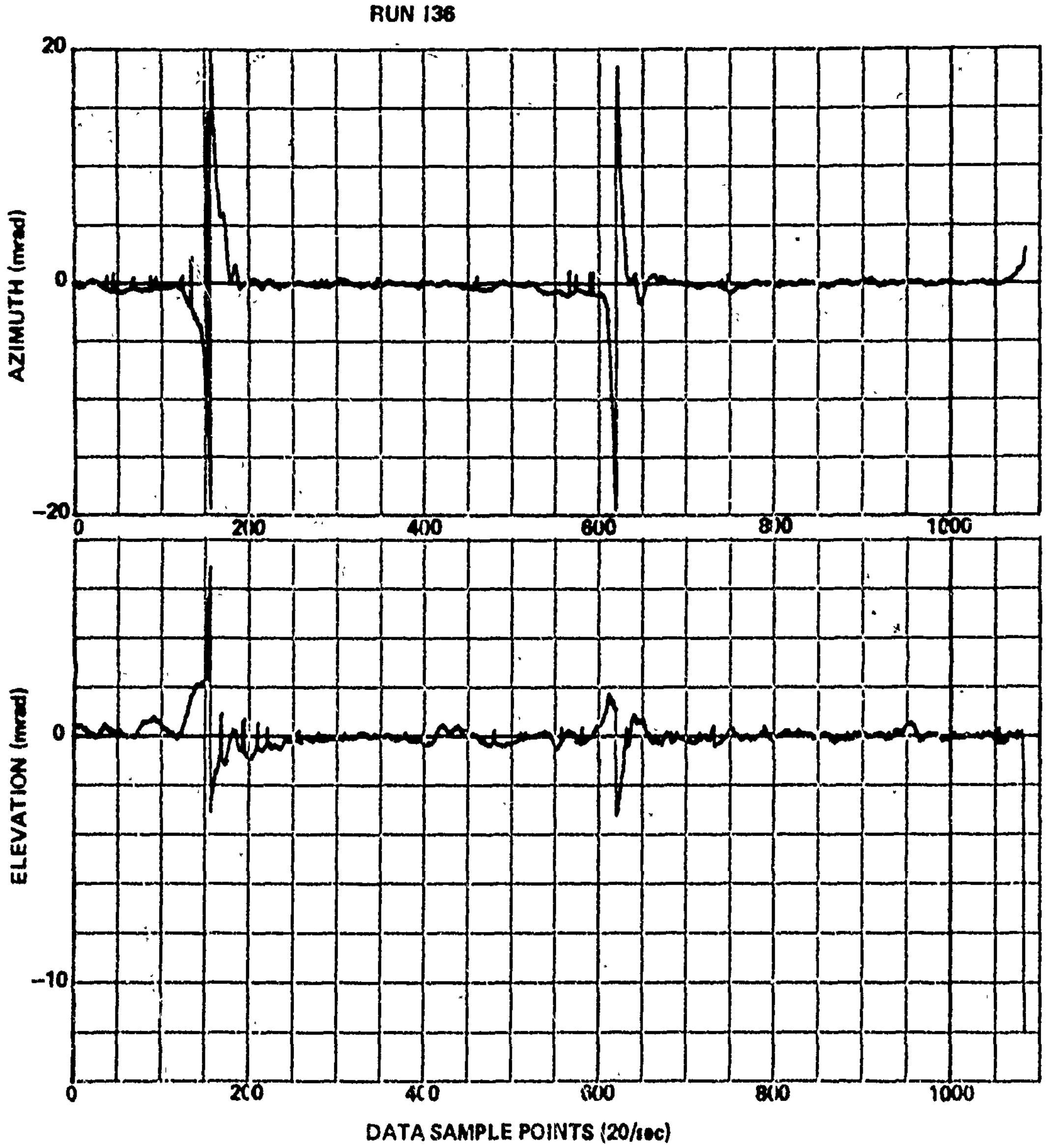
RUN 133



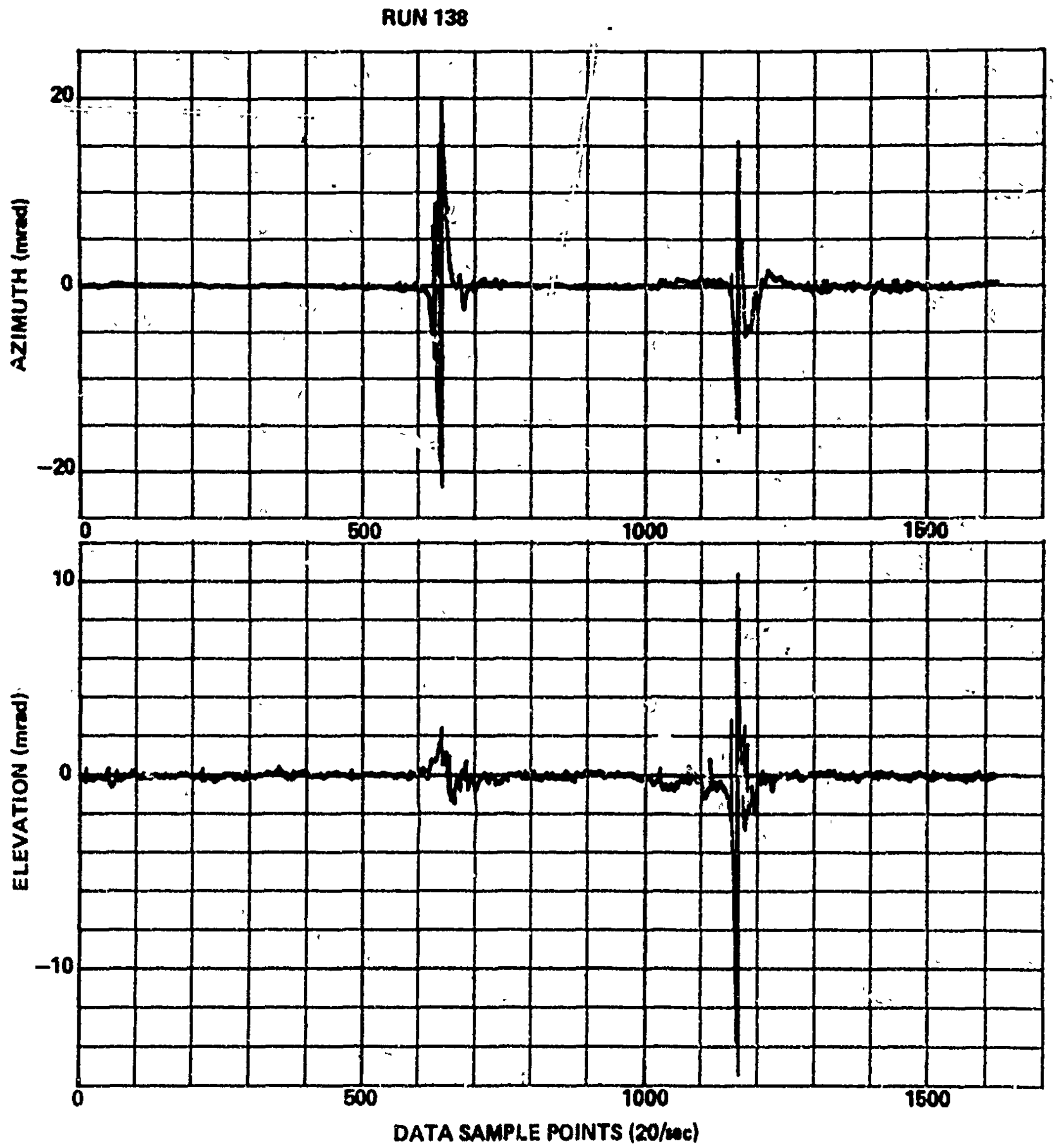
AZIMUTH (mrad)
0
0
500
1000
1500
ELEVATION (mrad)
10
0
−10
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)


RUN 134
AZIMUTH (mrad)
0.500
0.0
0
20
40
60
80
100
120
140
ELEVATION (mrad)
0.500
0.0
0
20
40
60
80
100
120
140
DATA SAMPLE POINTS (20/sec)

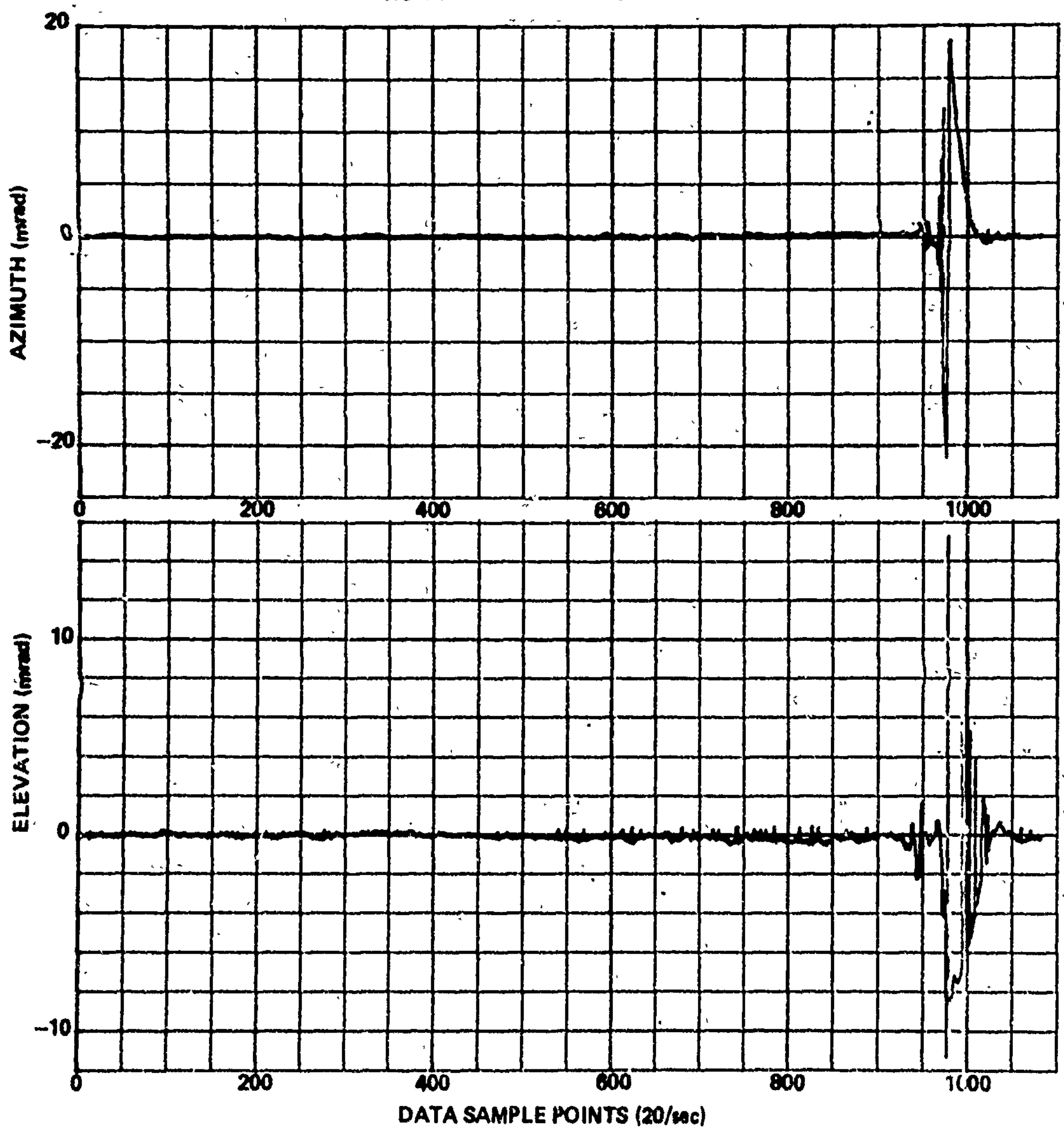

RUN 135
AZIMUTH (mrad)
5
0
-5
0
50
100
150
ELEVATION (mrad)
0
-10
0
50
100
150
DATA SAMPLE POINTS (20/sec)



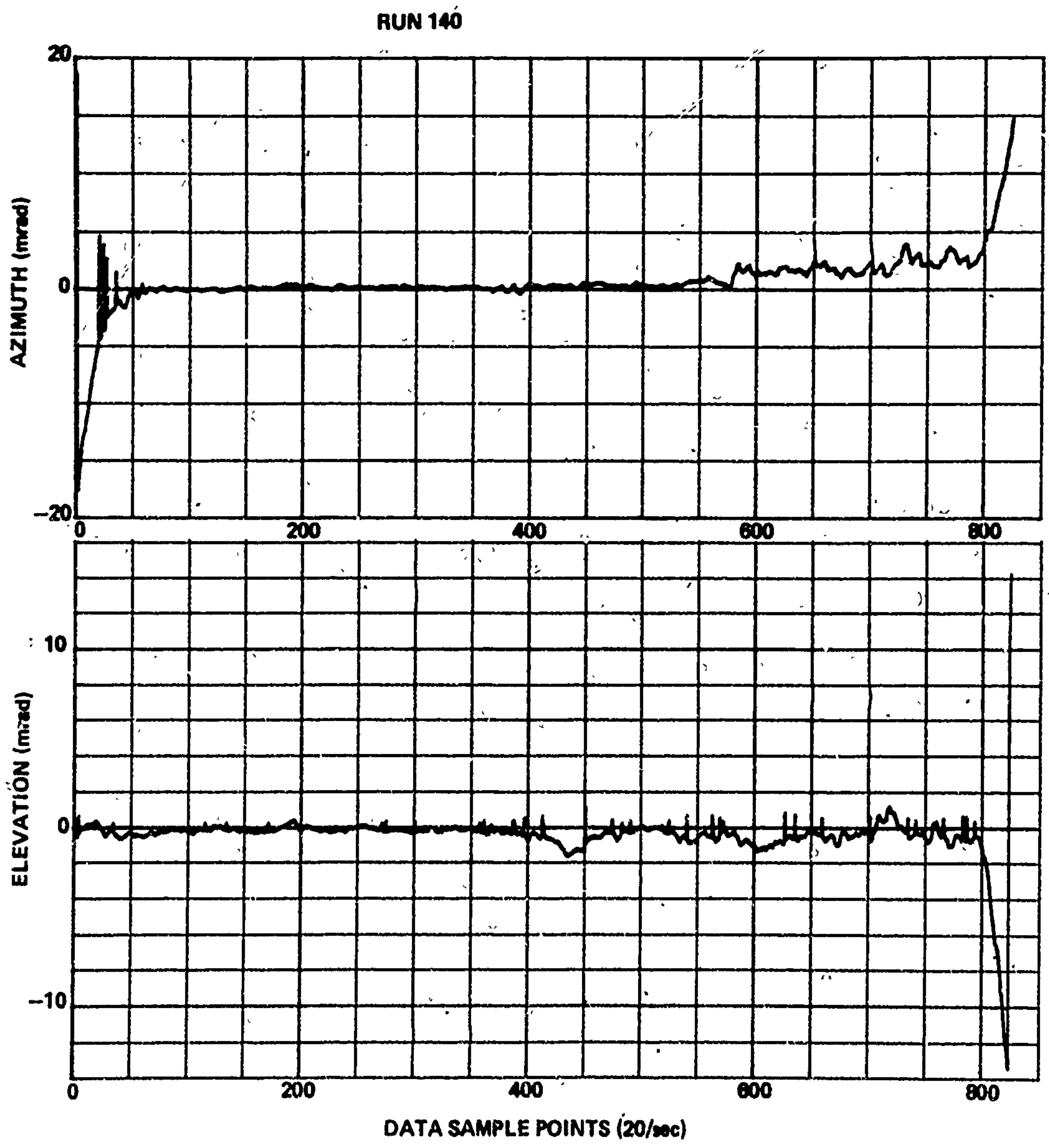
RUN 136
AZIMUTH (mrad)
ELEVATION (mrad)
20
0
-20
-10
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)

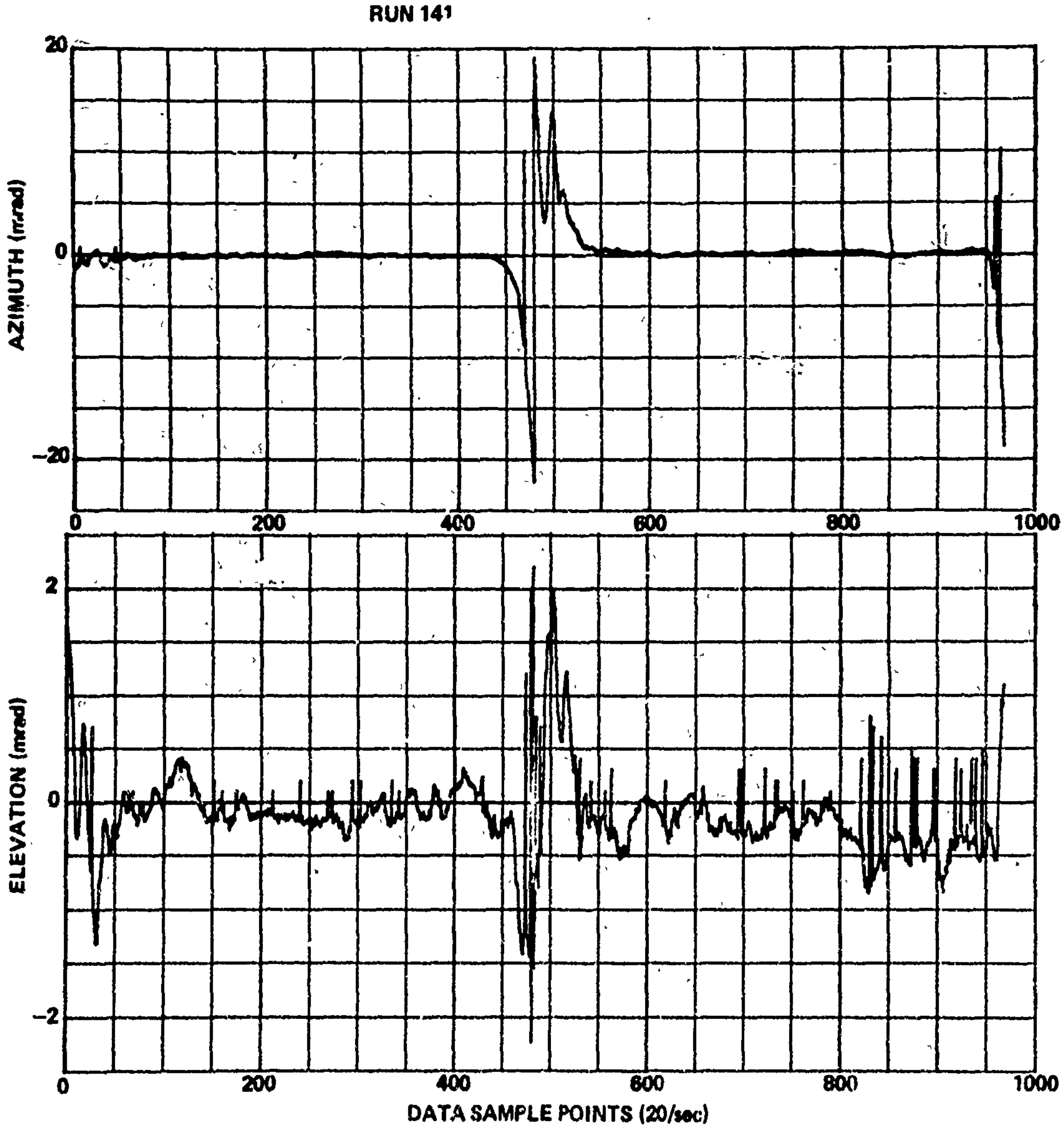

RUN 138
AZIMUTH (mrad)
20
0
−20
0
500
1000
1500
ELEVATION (mrad)
10
0
−10
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

RUN 139

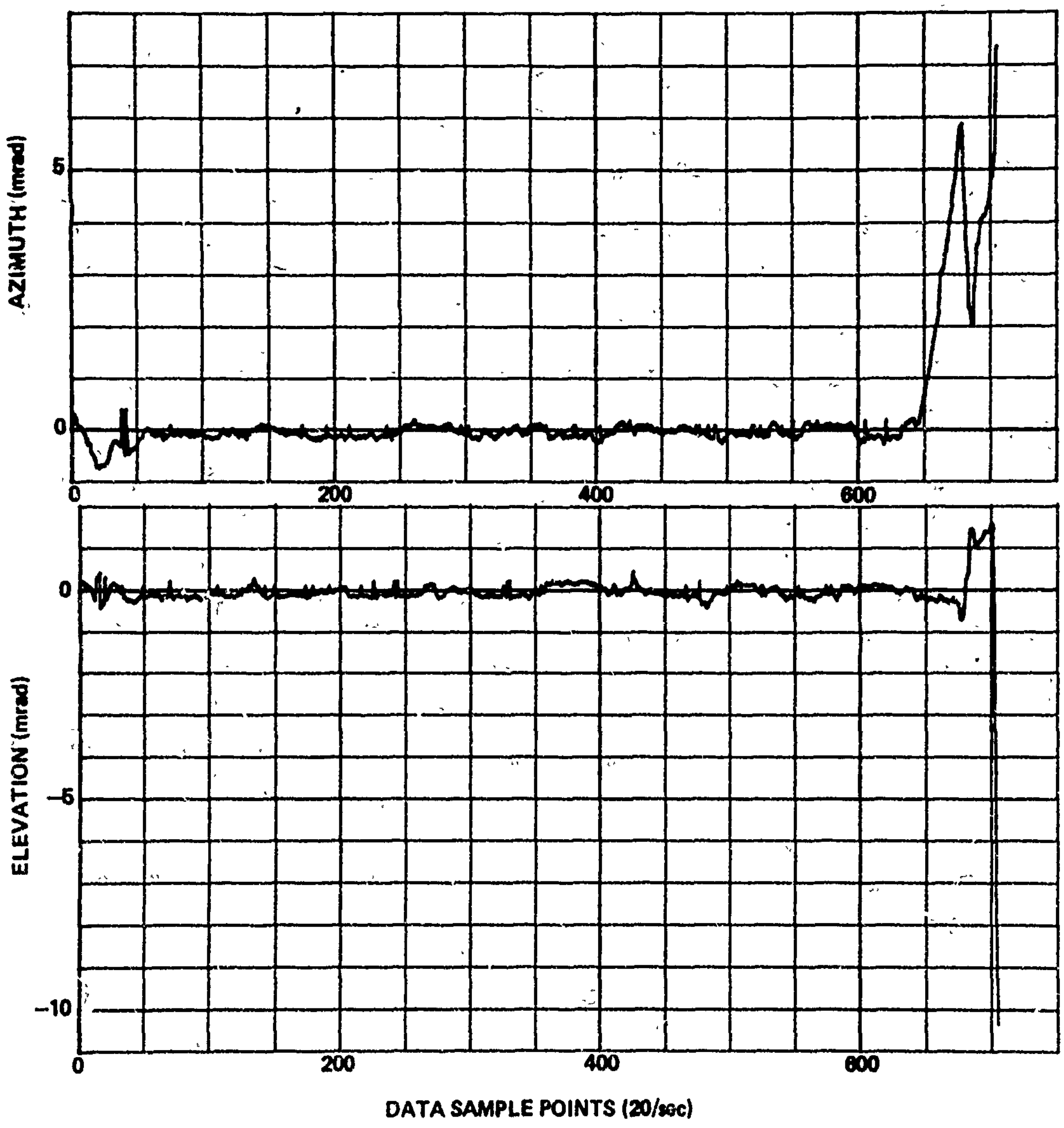


AZIMUTH (mrad)
20
0
-20
0
200
400
600
800
1000
ELEVATION (mrad)
10
0
-10
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)

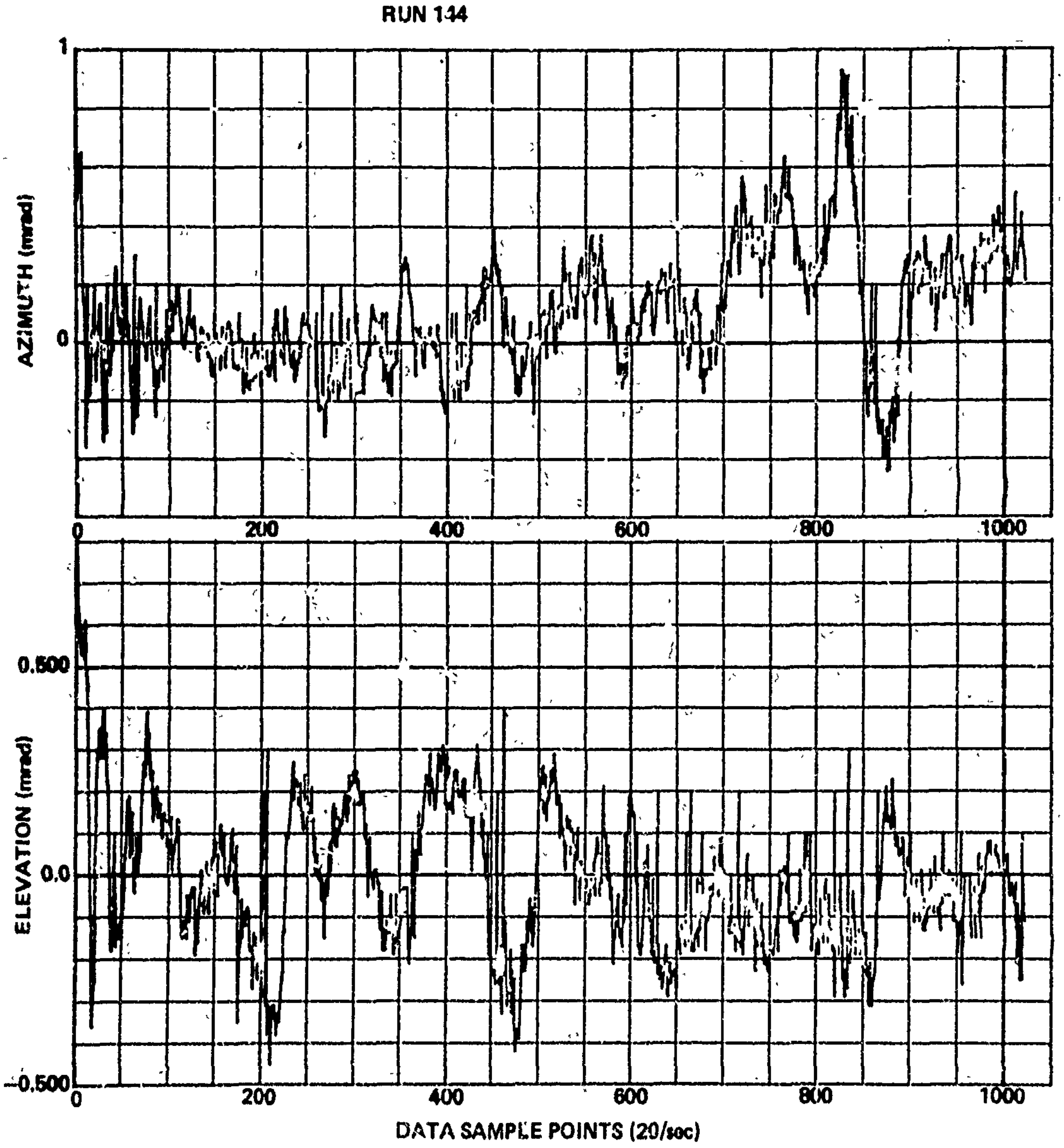

RUN 140
AZIMUTH (mrad)
20
0
−20
0
200
400
600
800
ELEVATION (mrad)
10
0
−10
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

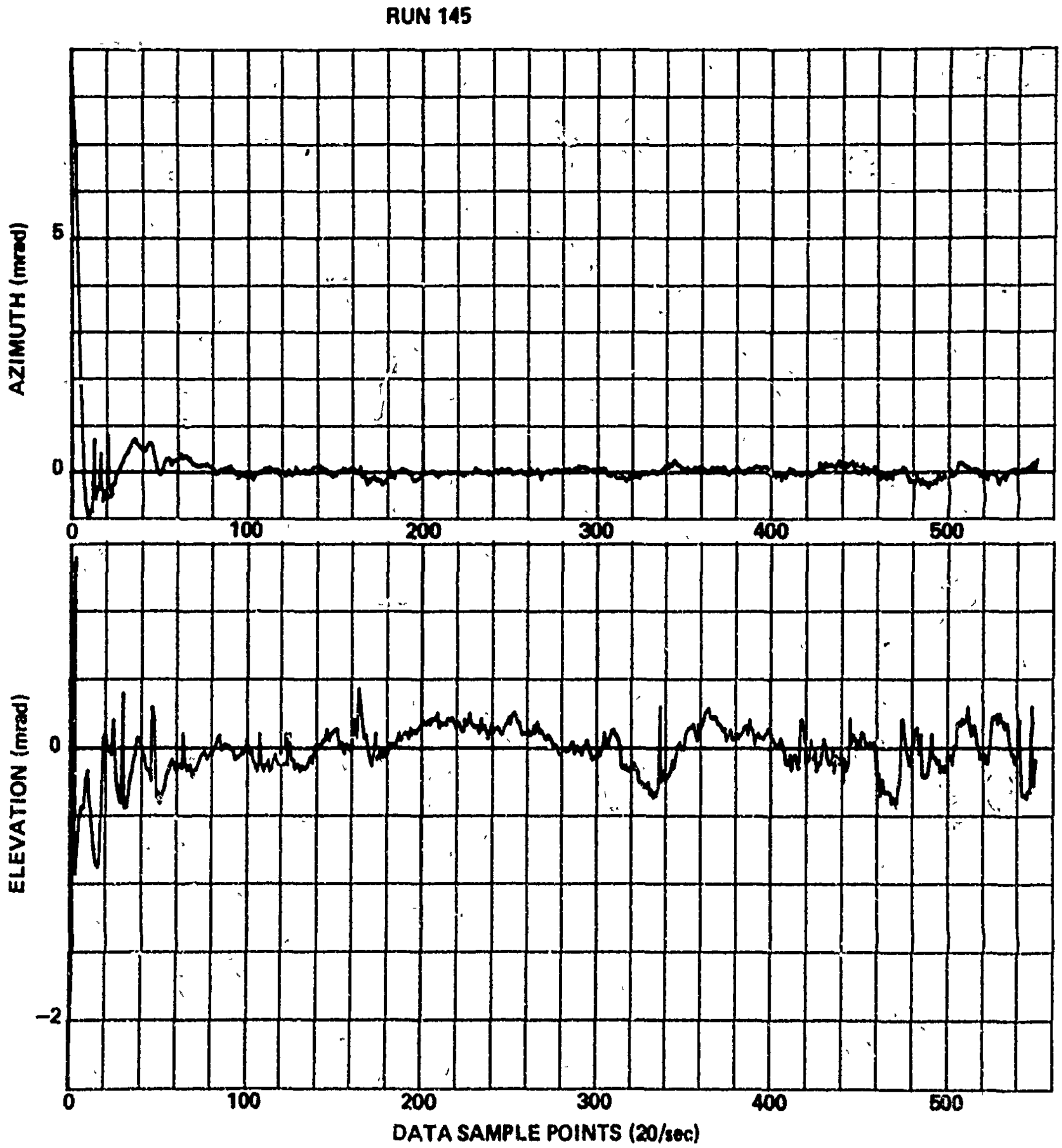

RUN 141
AZIMUTH (mrad)
20
0
-20
0
200
400
600
800
1000
ELEVATION (mrad)
2
0
-2
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)

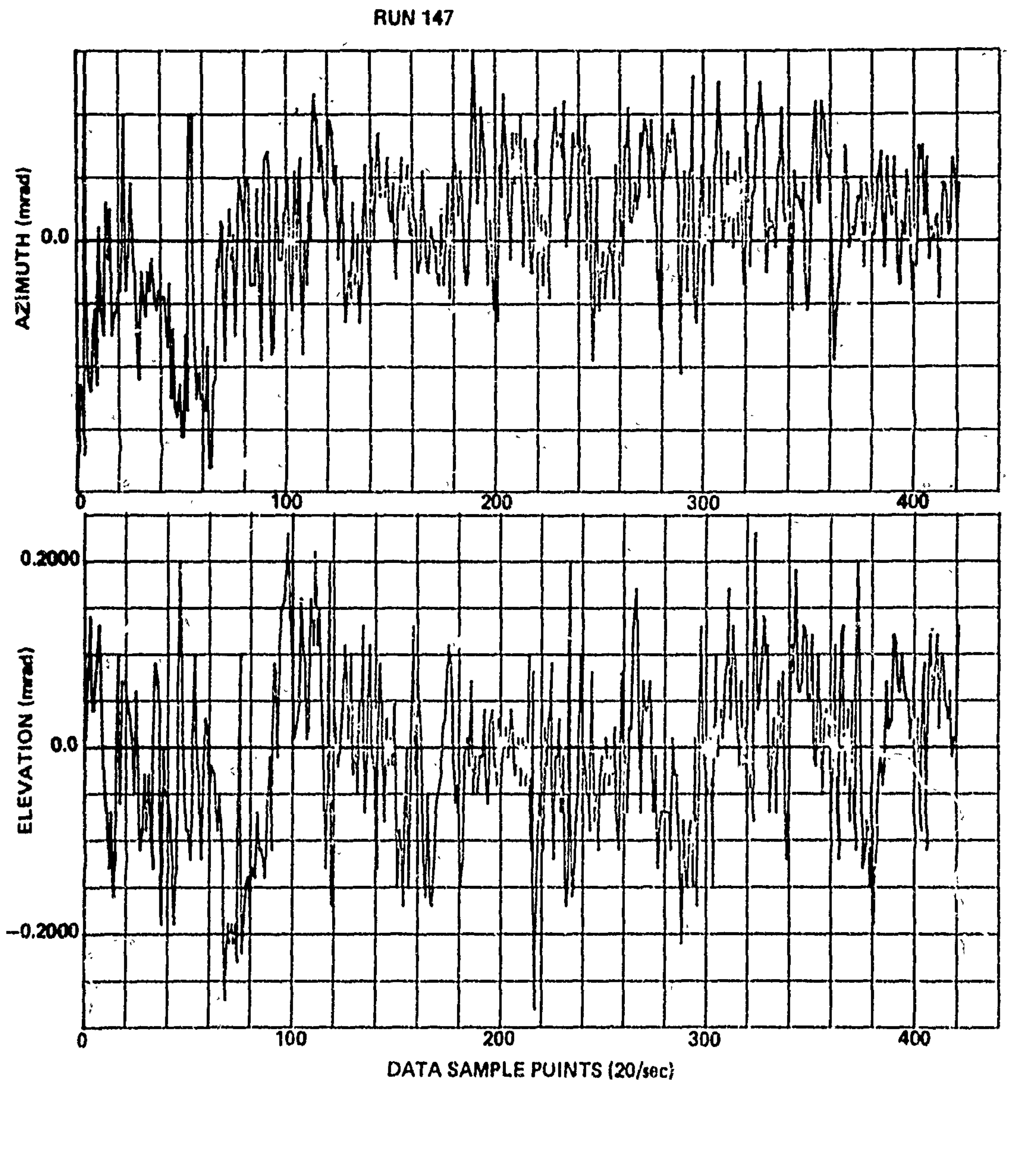
RUN 142

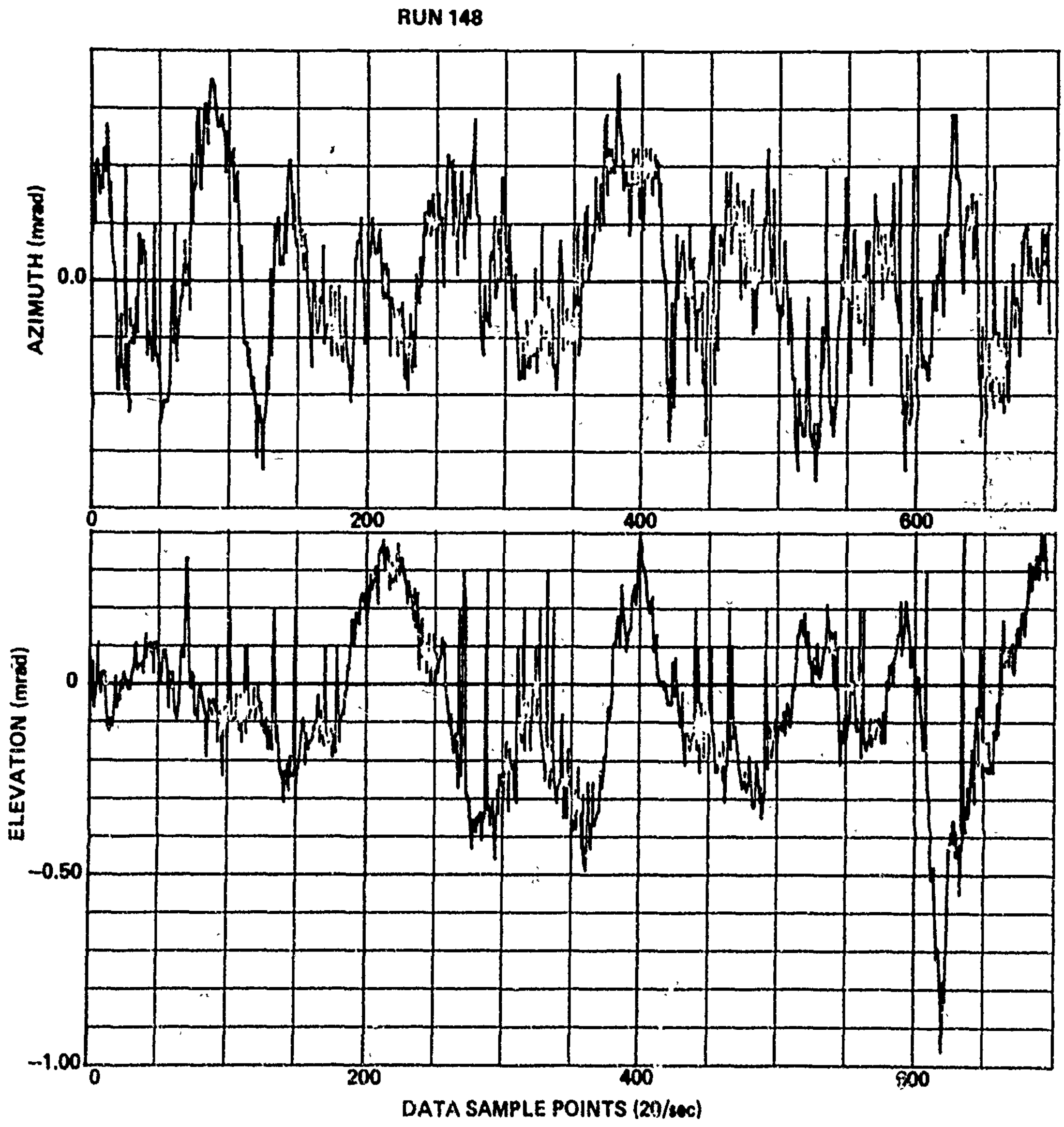


AZIMUTH (mrad)
5
0
0
200
400
600
ELEVATION (mrad)
0
-5
-10
0
200
400
600
DATA SAMPLE POINTS (20/sec)

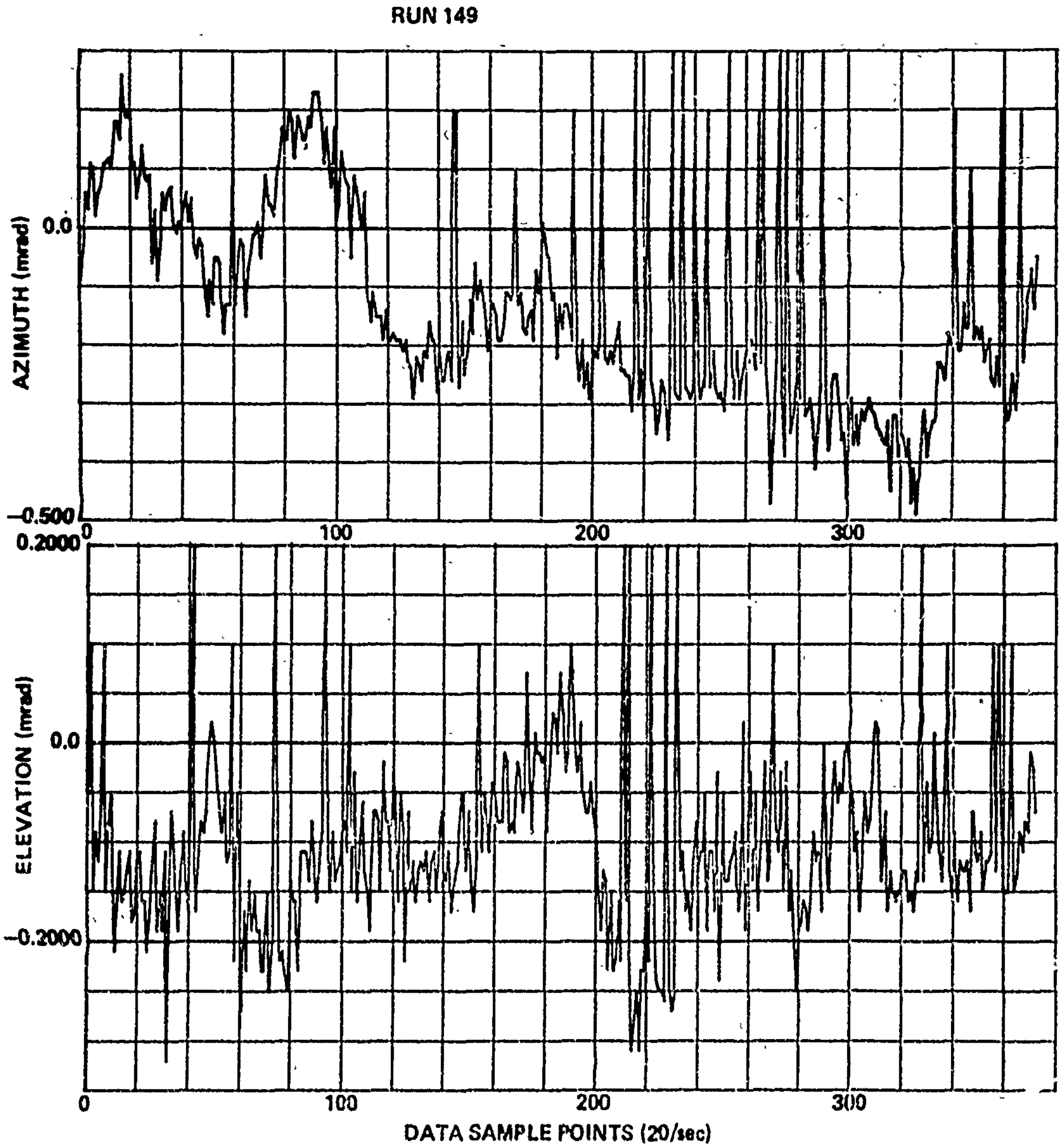

RUN 144
1
AZIMUTH (mrad)
0
0
200
400
600
800
1000
0.500
ELEVATION (mrad)
0.0
-0.500
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)


RUN 145
AZIMUTH (mrad)
5
0
0
100
200
300
400
500
ELEVATION (mrad)
0
-2
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

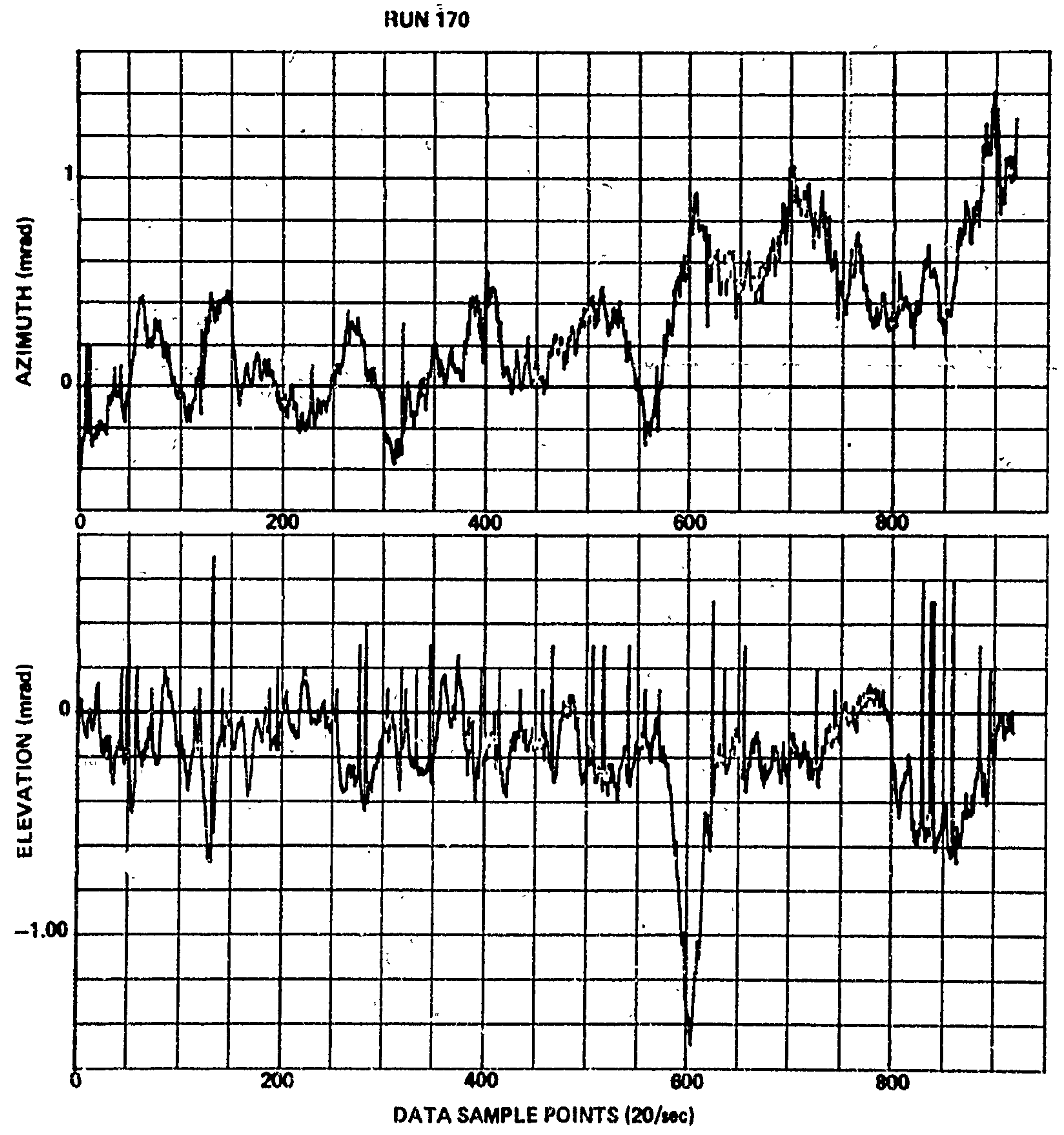

RUN 147
AZIMUTH (mrad)
0.0
0
100
200
300
400
ELEVATION (mrad)
0.2000
0.0
-0.2000
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)

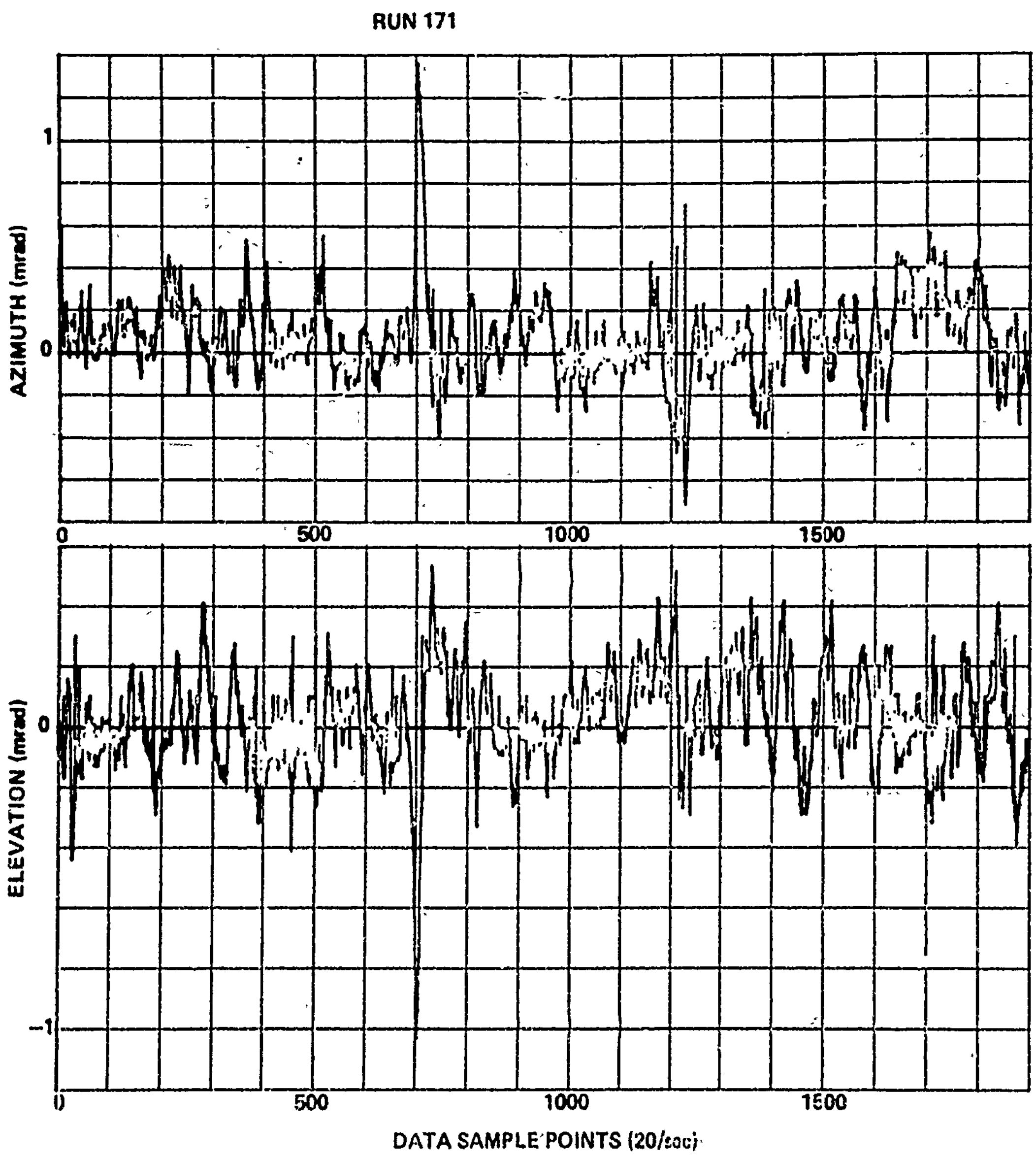


RUN 148
AZIMUTH (mrad)
0.0
0
200
400
600
ELEVATION (mrad)
0
−0.50
−1.00
0
200
400
600
DATA SAMPLE POINTS (20/sec)



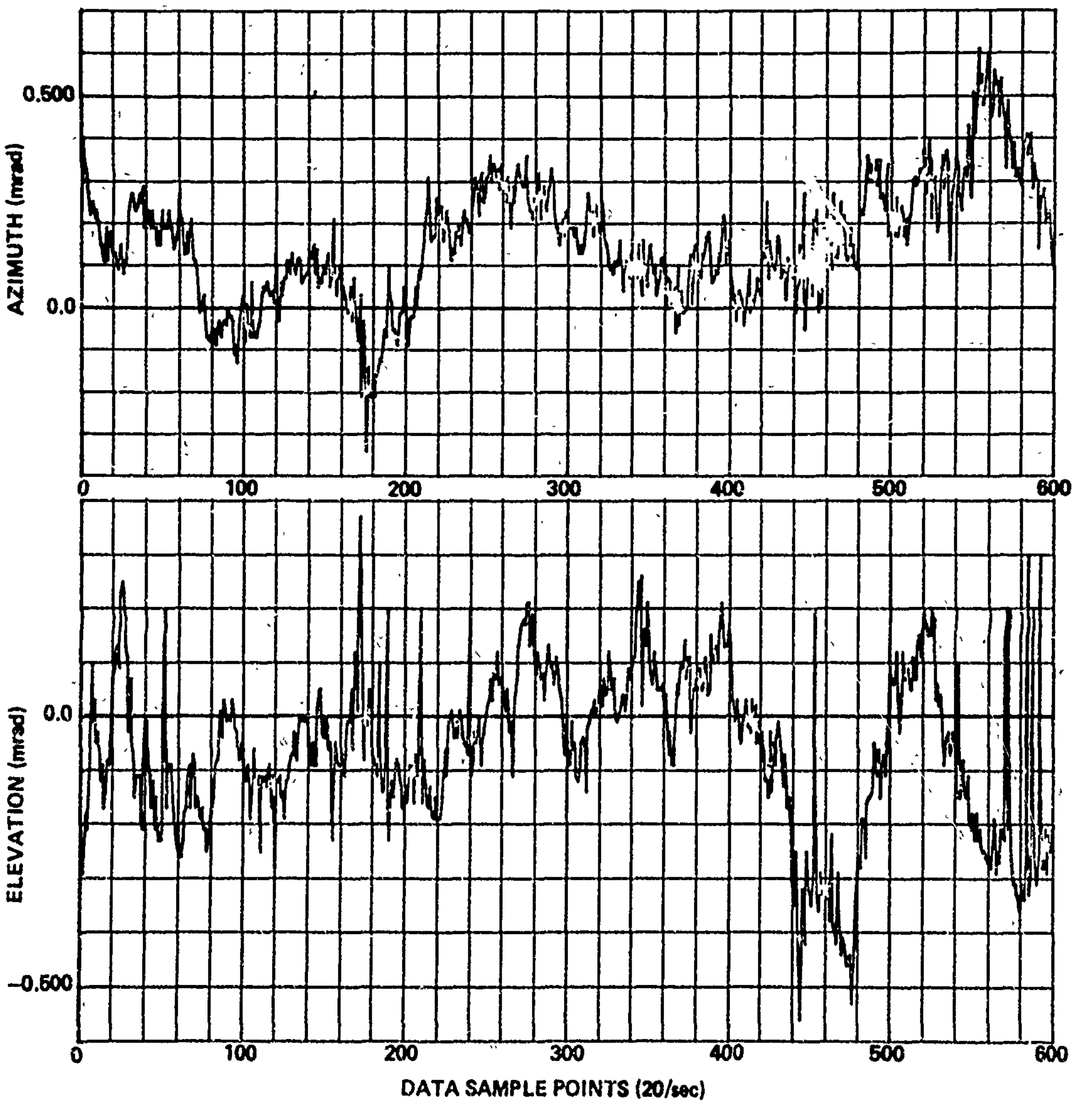
RUN 149
AZIMUTH (mrad)
0.0
-0.500
0
100
200
300
0.2000
ELEVATION (mrad)
0.0
-0.2000
0
100
200
300
DATA SAMPLE POINTS (20/sec)


RUN 170
AZIMUTH (mrad)
1
0
200
400
600
800
ELEVATION (mrad)
0
−1.00
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

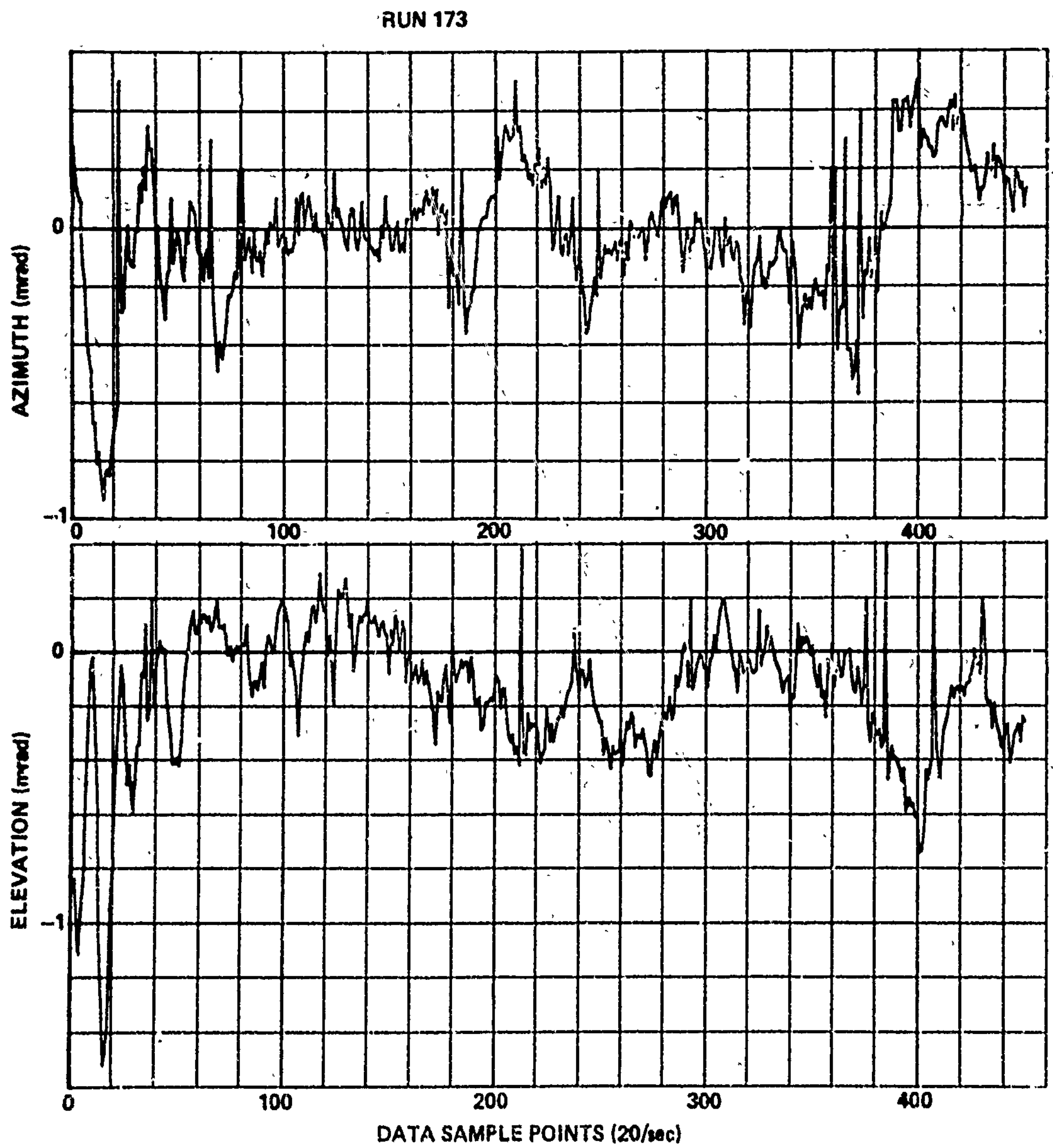


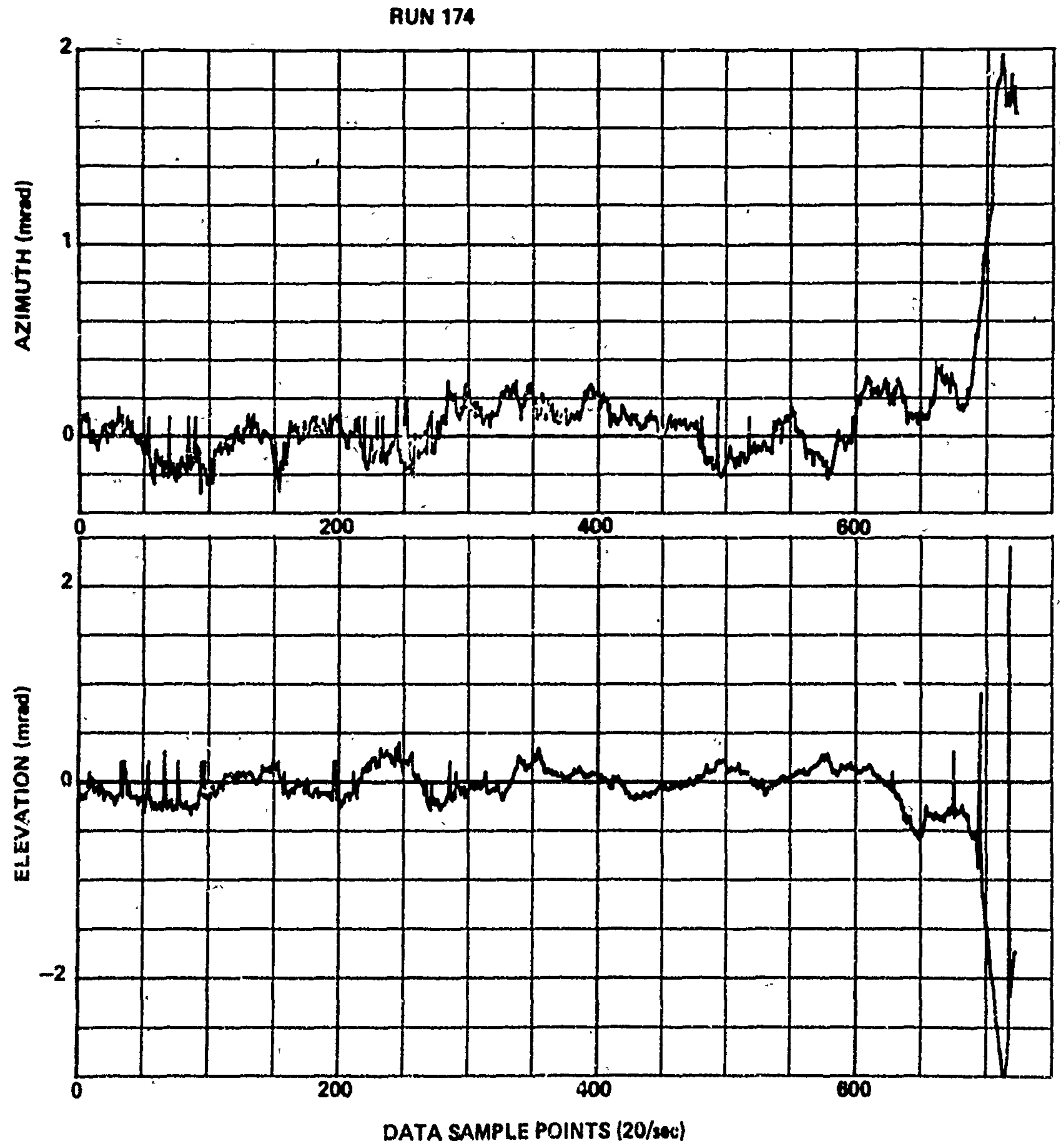
RUN 171
AZIMUTH (mrad)
1
0
0
500
1000
1500
ELEVATION (mrad)
0
−1
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

RUN 172

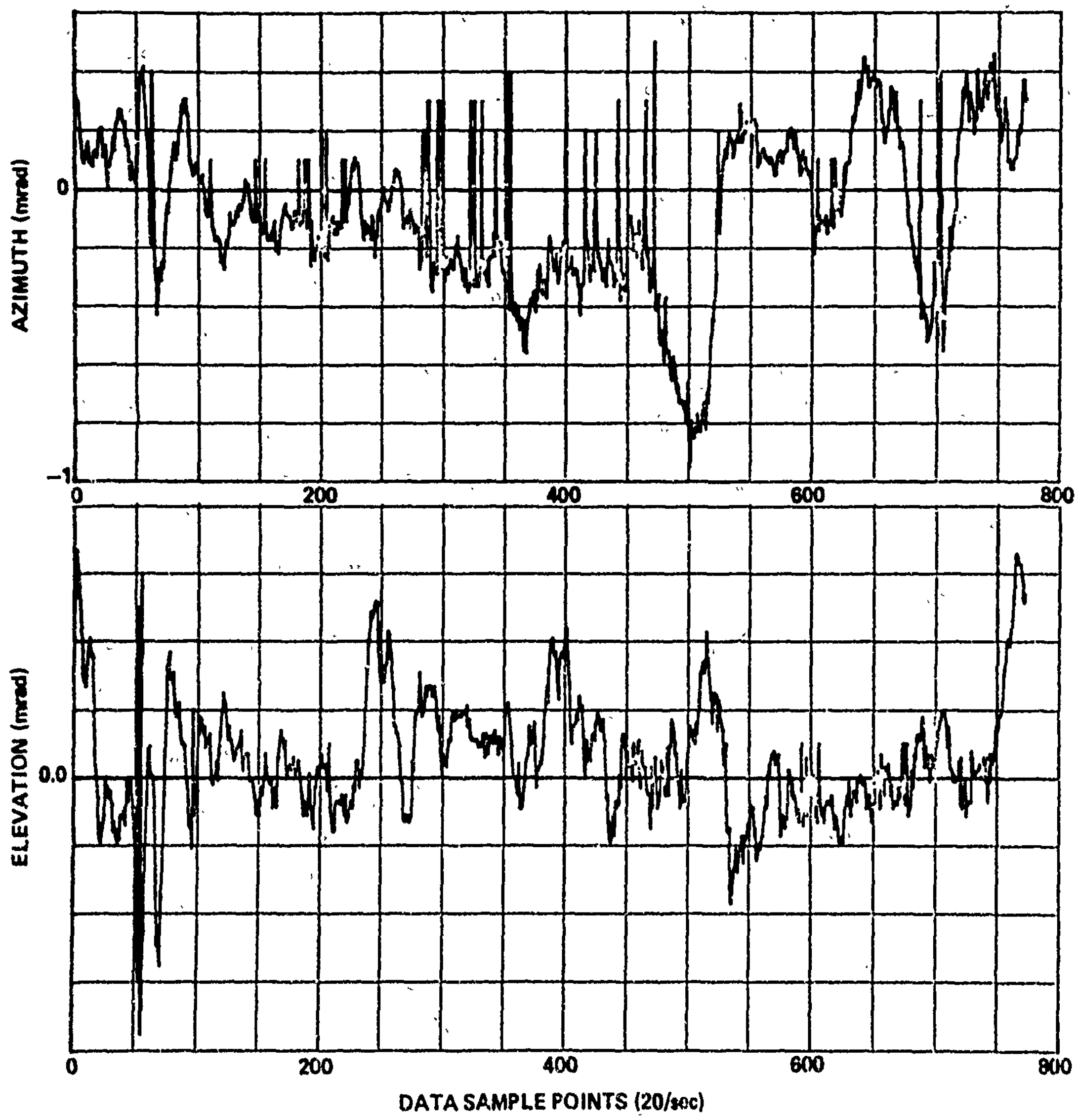


0.500
0.0
AZIMUTH (mrad)
0
100
200
300
400
500
600
0.0
-0.500
ELEVATION (mrad)
0
100
200
300
400
500
600
DATA SAMPLE POINTS (20/sec)

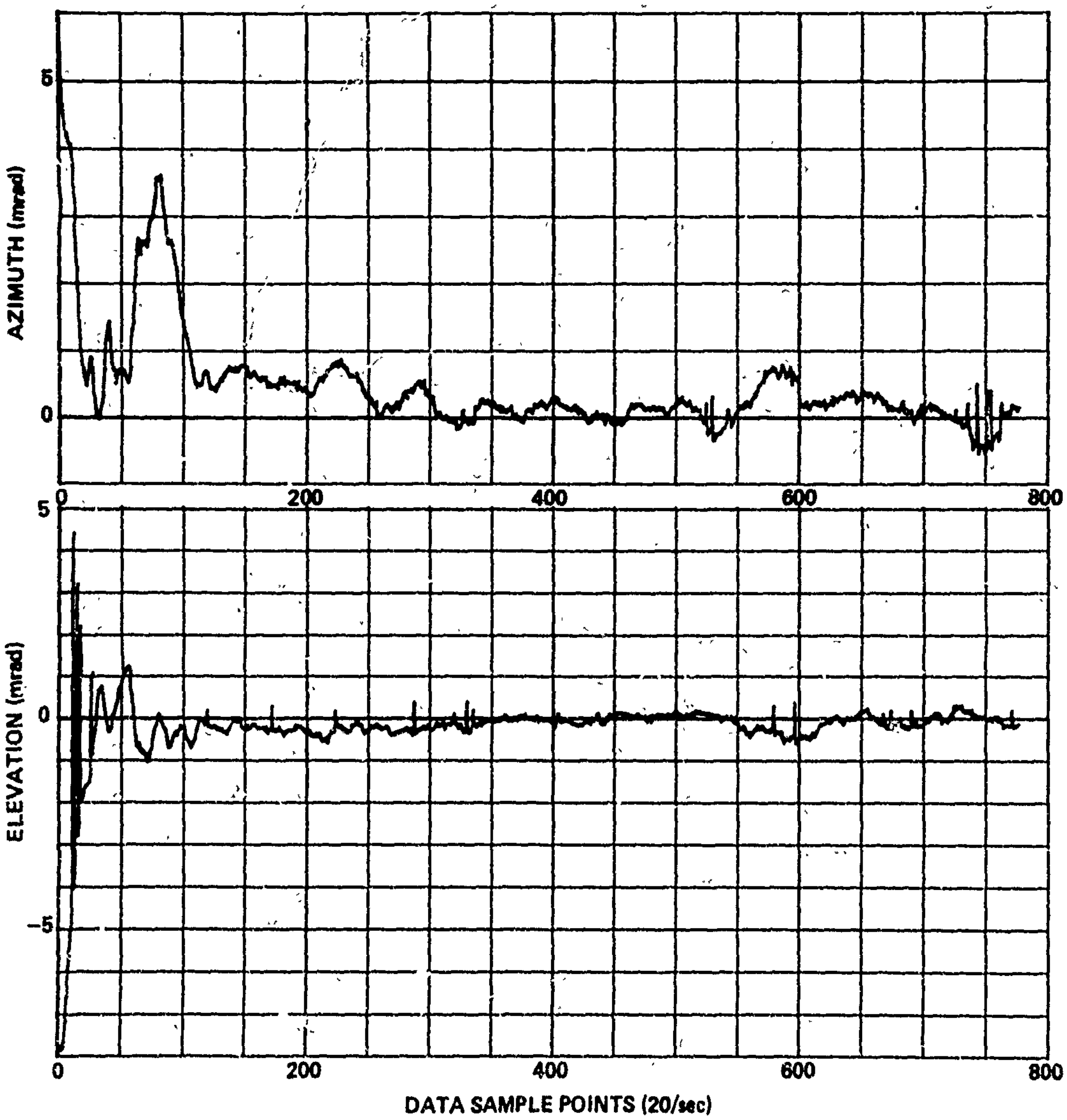

RUN 173
AZIMUTH (mrad)
0
–1
0
100
200
300
400
ELEVATION (mrad)
0
–1
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)


RUN 174
AZIMUTH (mrad)
2
1
0
0
200
400
600
ELEVATION (mrad)
2
0
−2
0
200
400
600
DATA SAMPLE POINTS (20/sec)

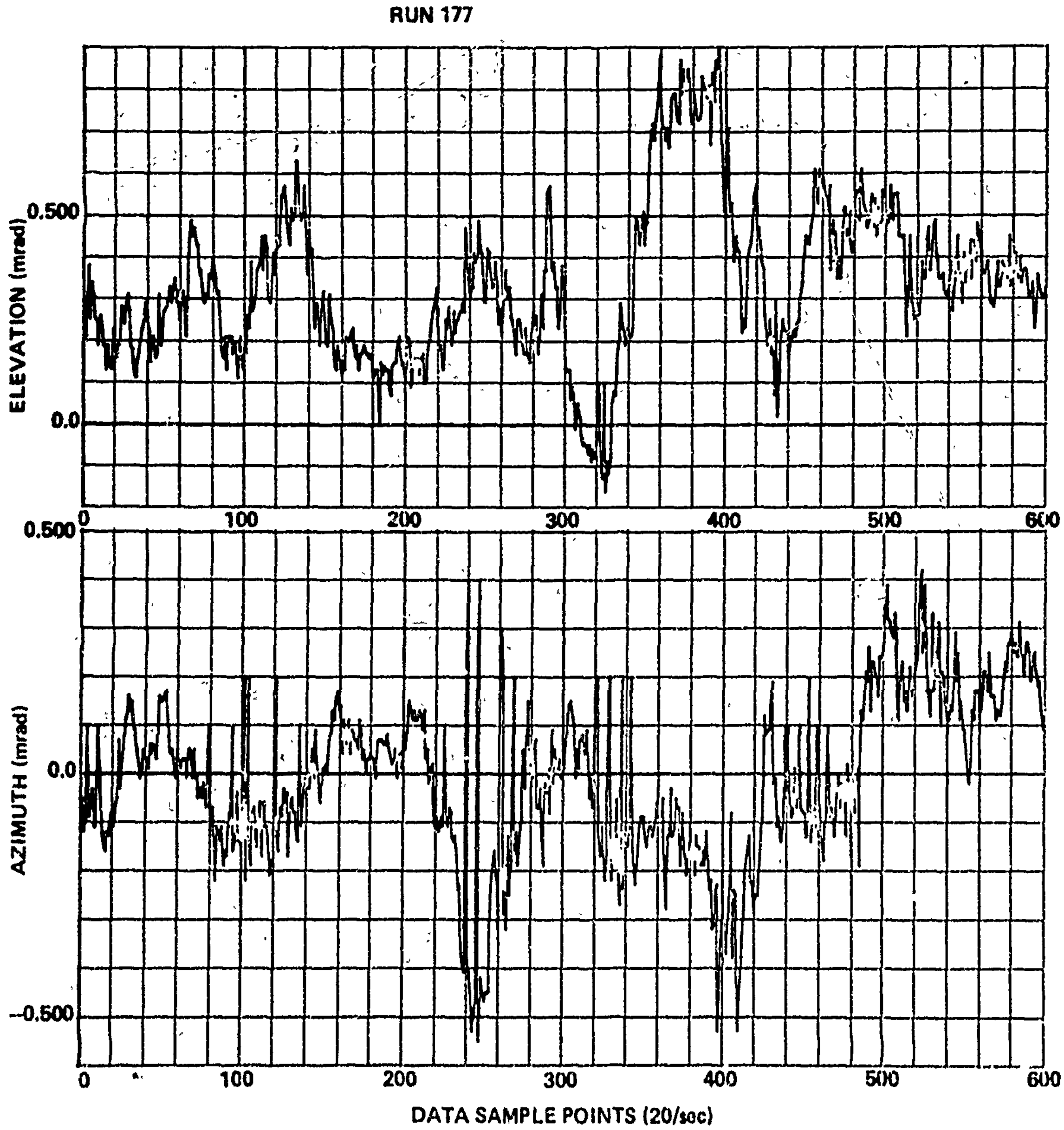
RUN 175

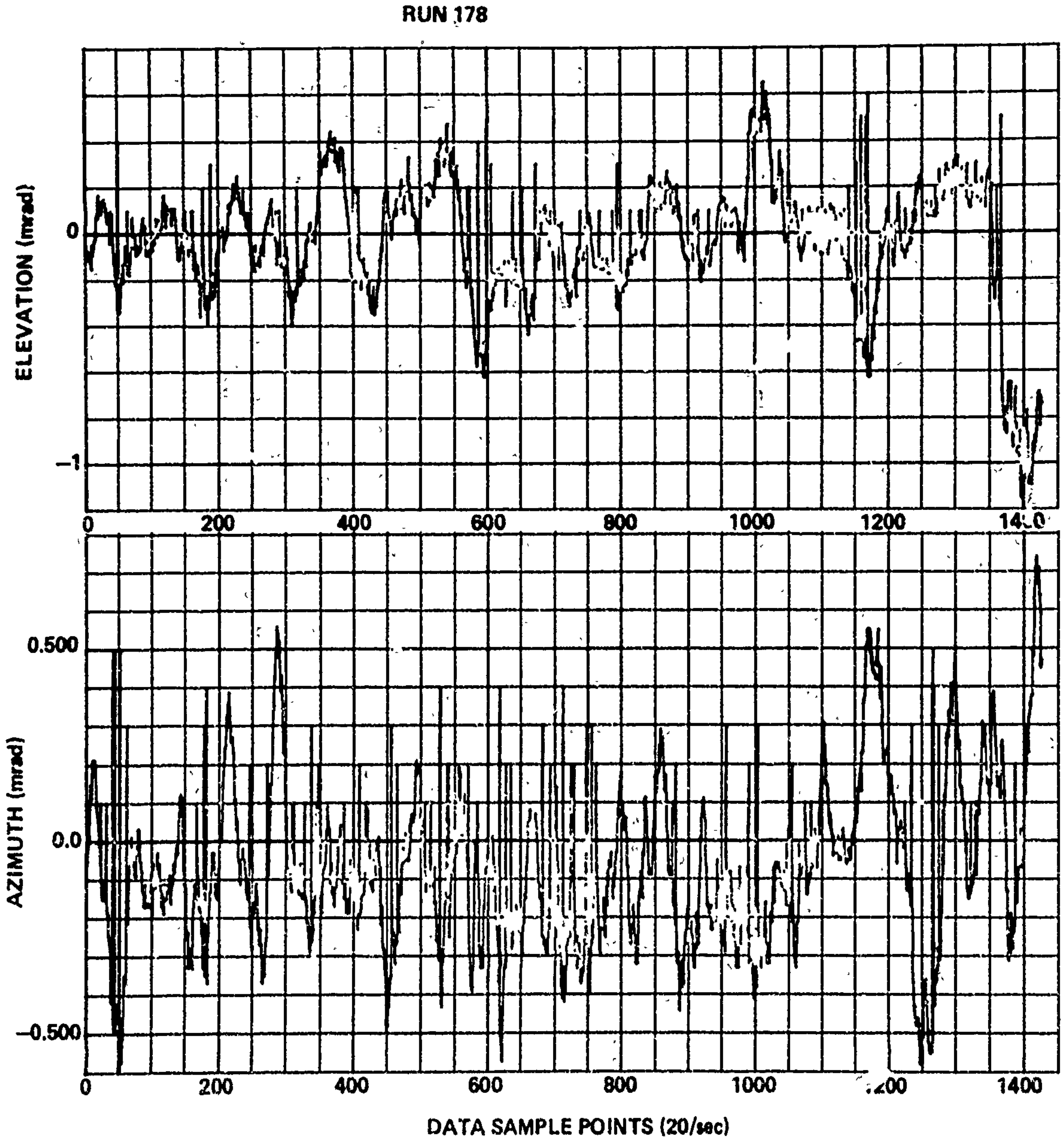

AZIMUTH (mrad)
0
-1
0
200
400
600
800
ELEVATION (mrad)
0.0
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

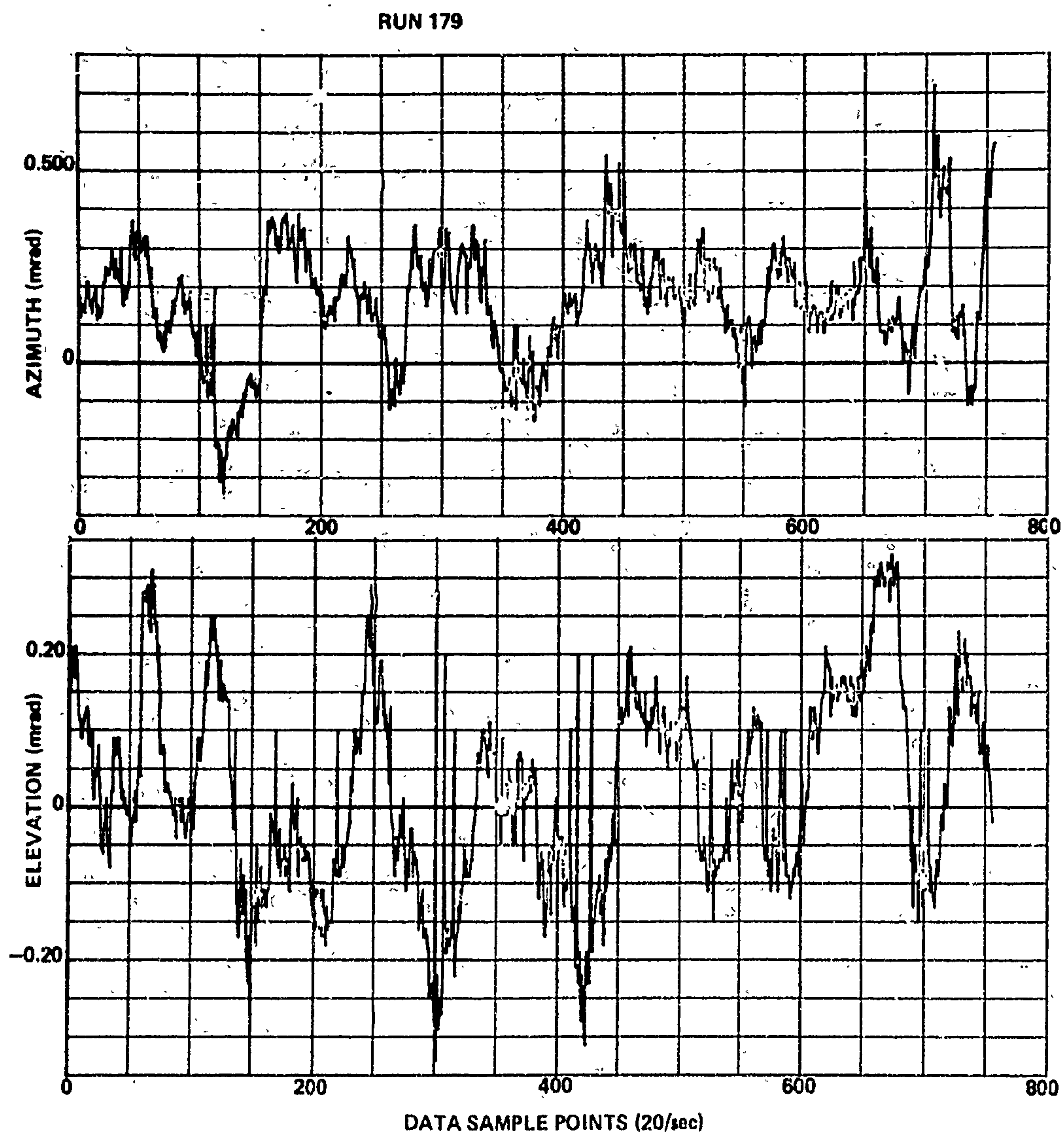
RUN 176



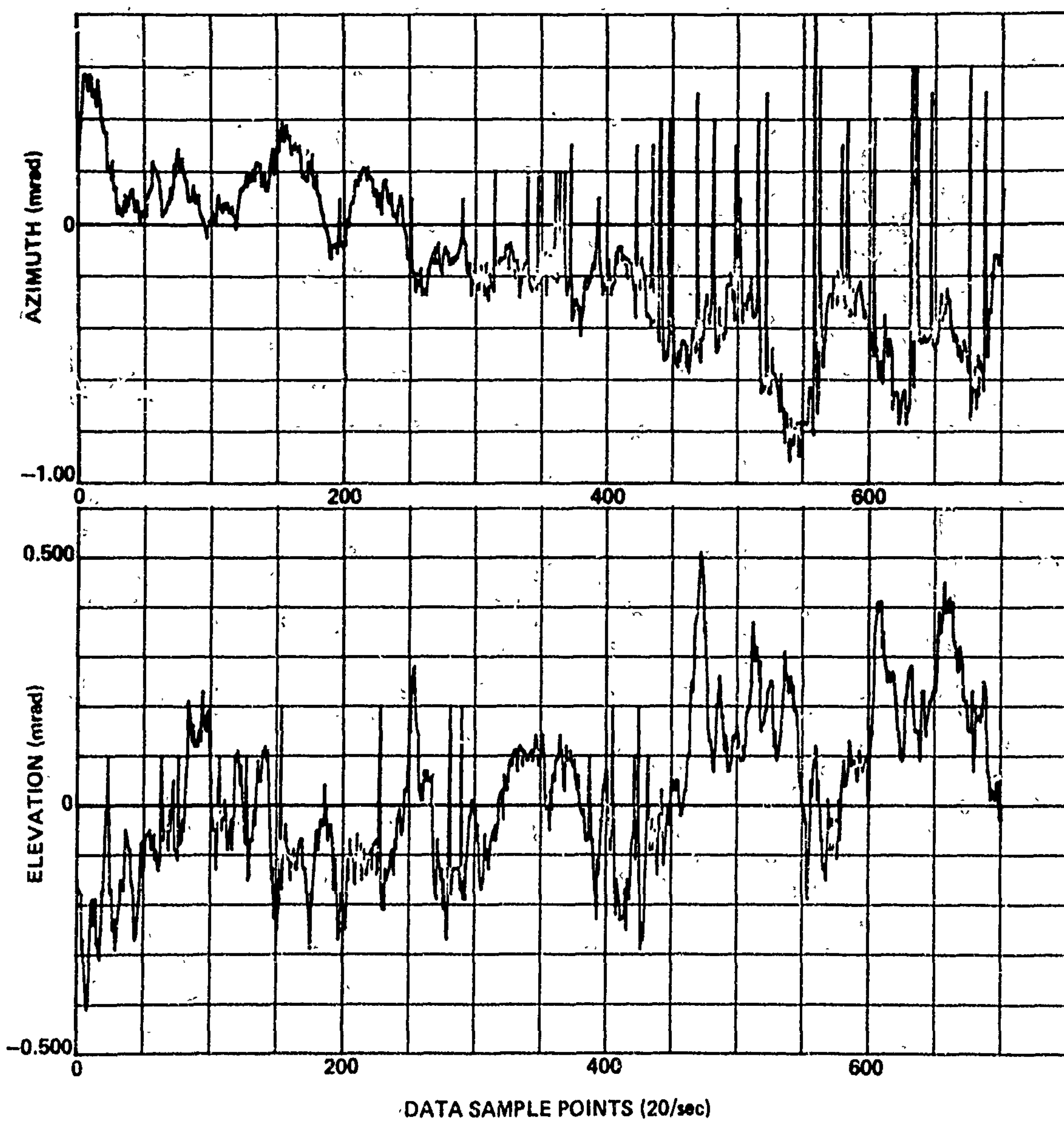
5
0
AZIMUTH (mrad)
0
200
400
600
800
5
0
-5
ELEVATION (mrad)
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)


RUN 177
ELEVATION (mrad)
0.500
0.0
0
100
200
300
400
500
600
0.500
AZIMUTH (mrad)
0.0
-0.500
0
100
200
300
400
500
600
DATA SAMPLE POINTS (20/sec)

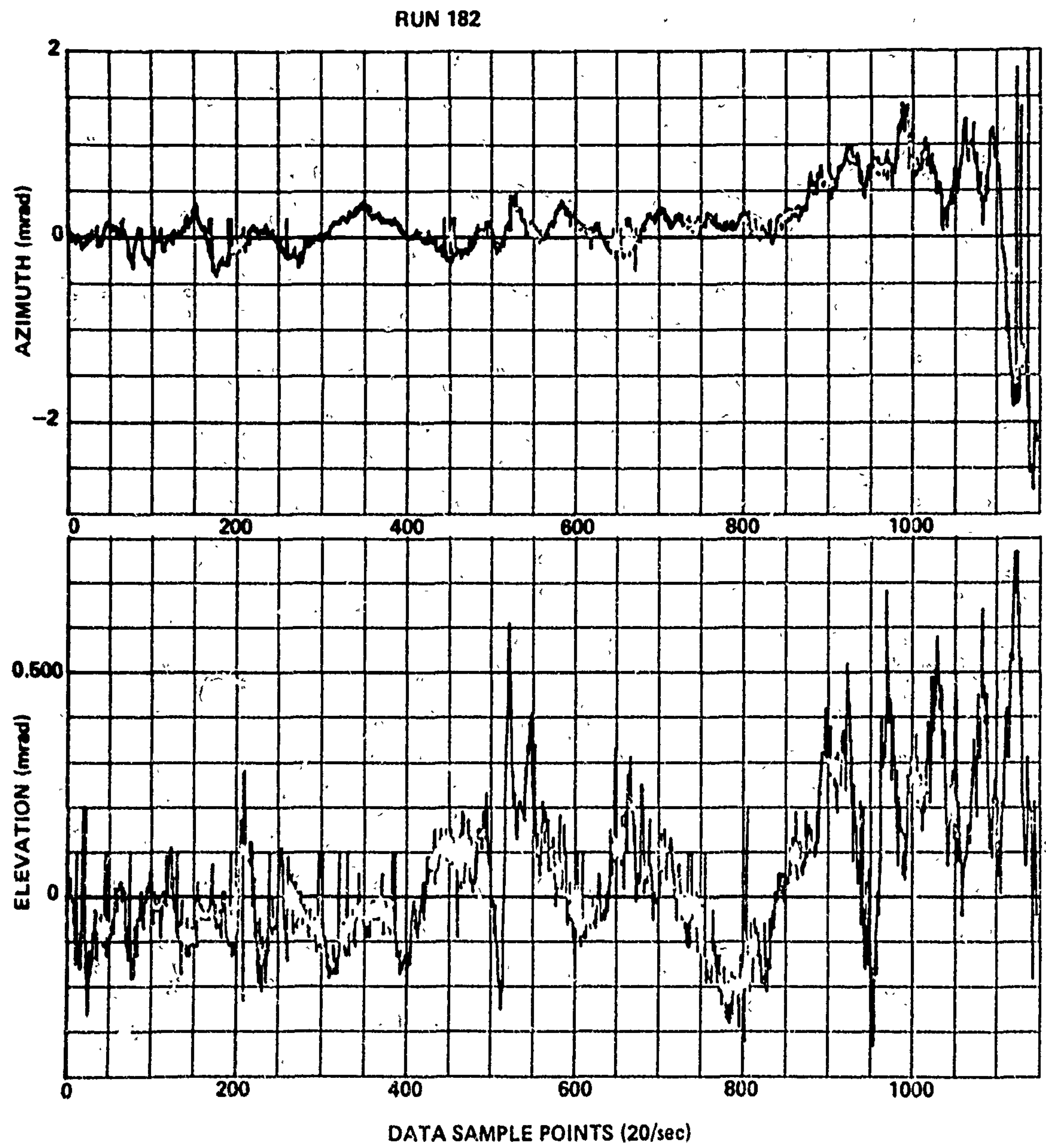

RUN 178
ELEVATION (mrad)
0
−1
0
200
400
600
800
1000
1200
AZIMUTH (mrad)
0.500
0.0
−0.500
0
200
400
600
800
1000
1400
DATA SAMPLE POINTS (20/sec)


RUN 179
AZIMUTH (mrad)
0.500
0
0
200
400
600
800
ELEVATION (mrad)
0.20
0
−0.20
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

RUN 180

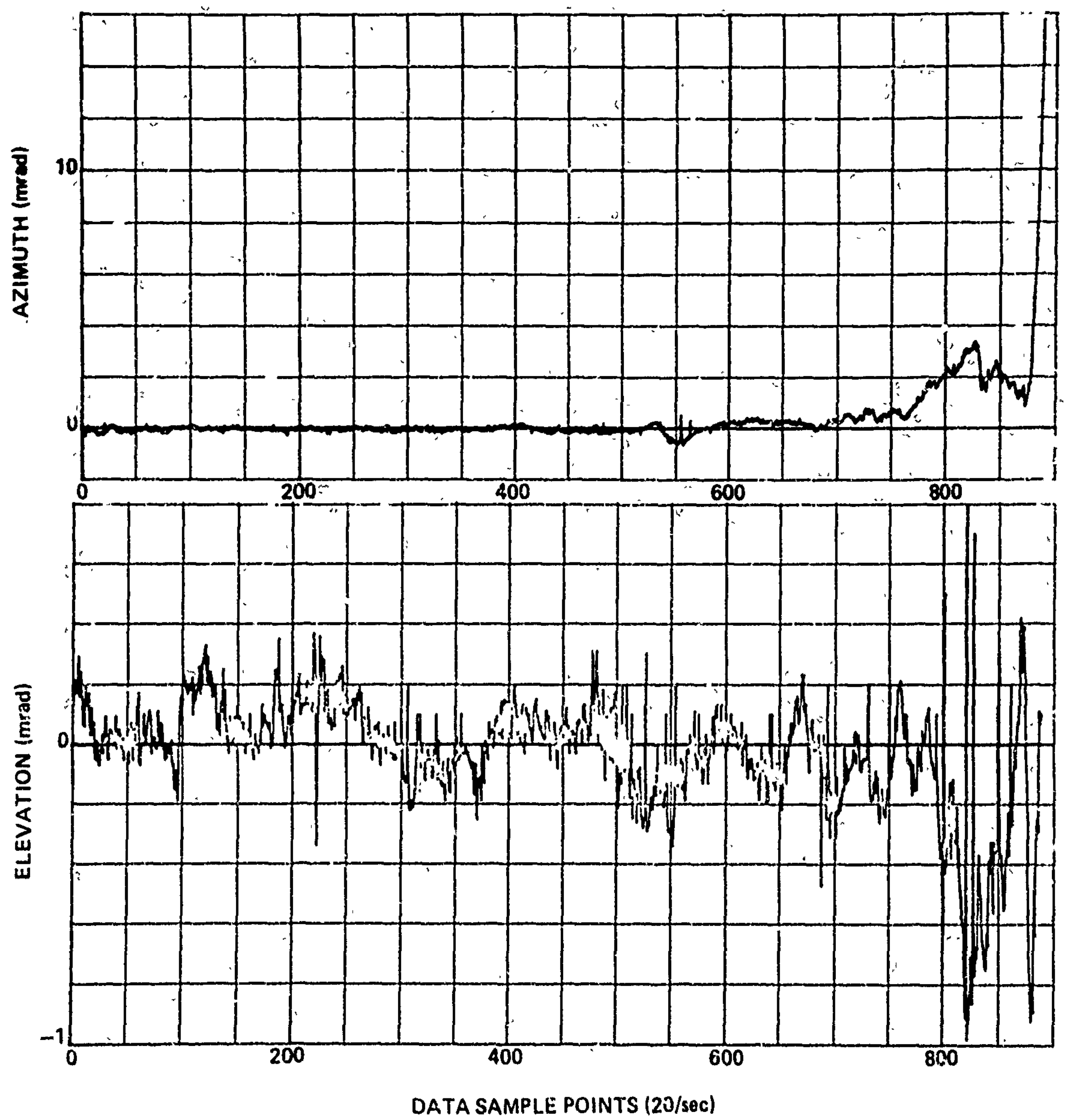


AZIMUTH (mrad)
0
–1.00
0
200
400
600
ELEVATION (mrad)
0.500
0
–0.500
0
200
400
600
DATA SAMPLE POINTS (20/sec)

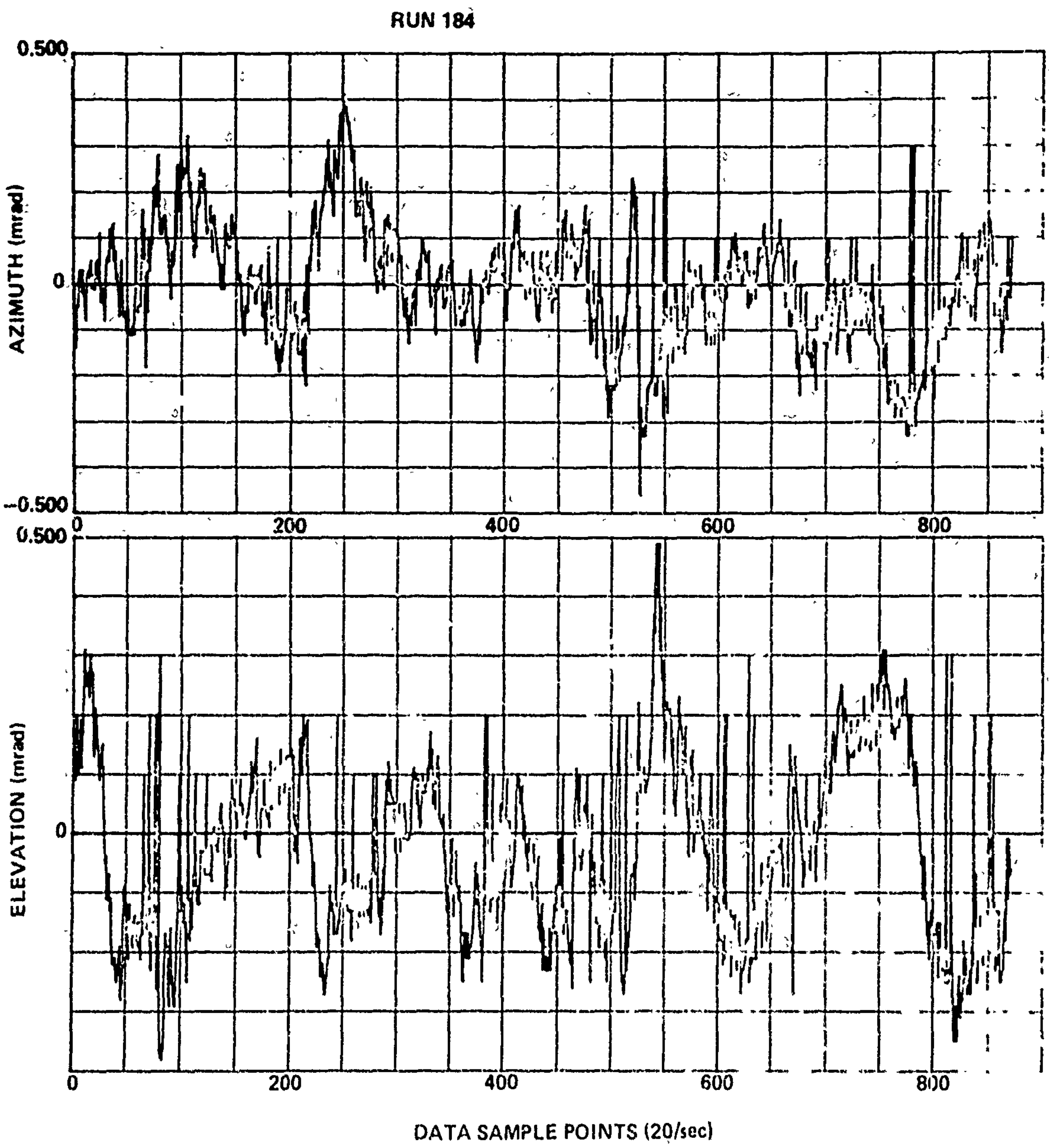


RUN 182
2
0
-2
AZIMUTH (mrad)
0
200
400
600
800
1000
0.500
0
ELEVATION (mrad)
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)

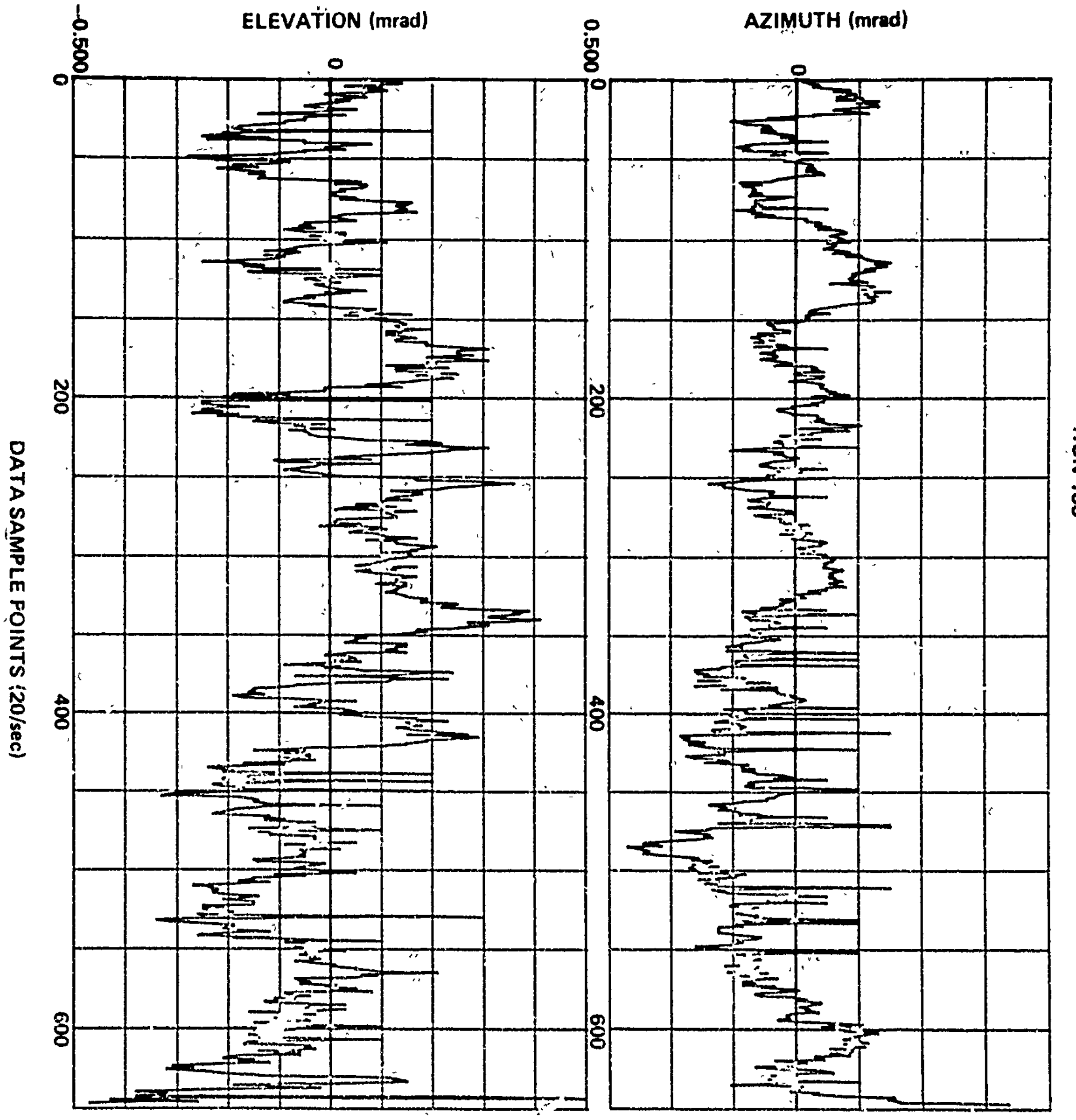
RUN 183



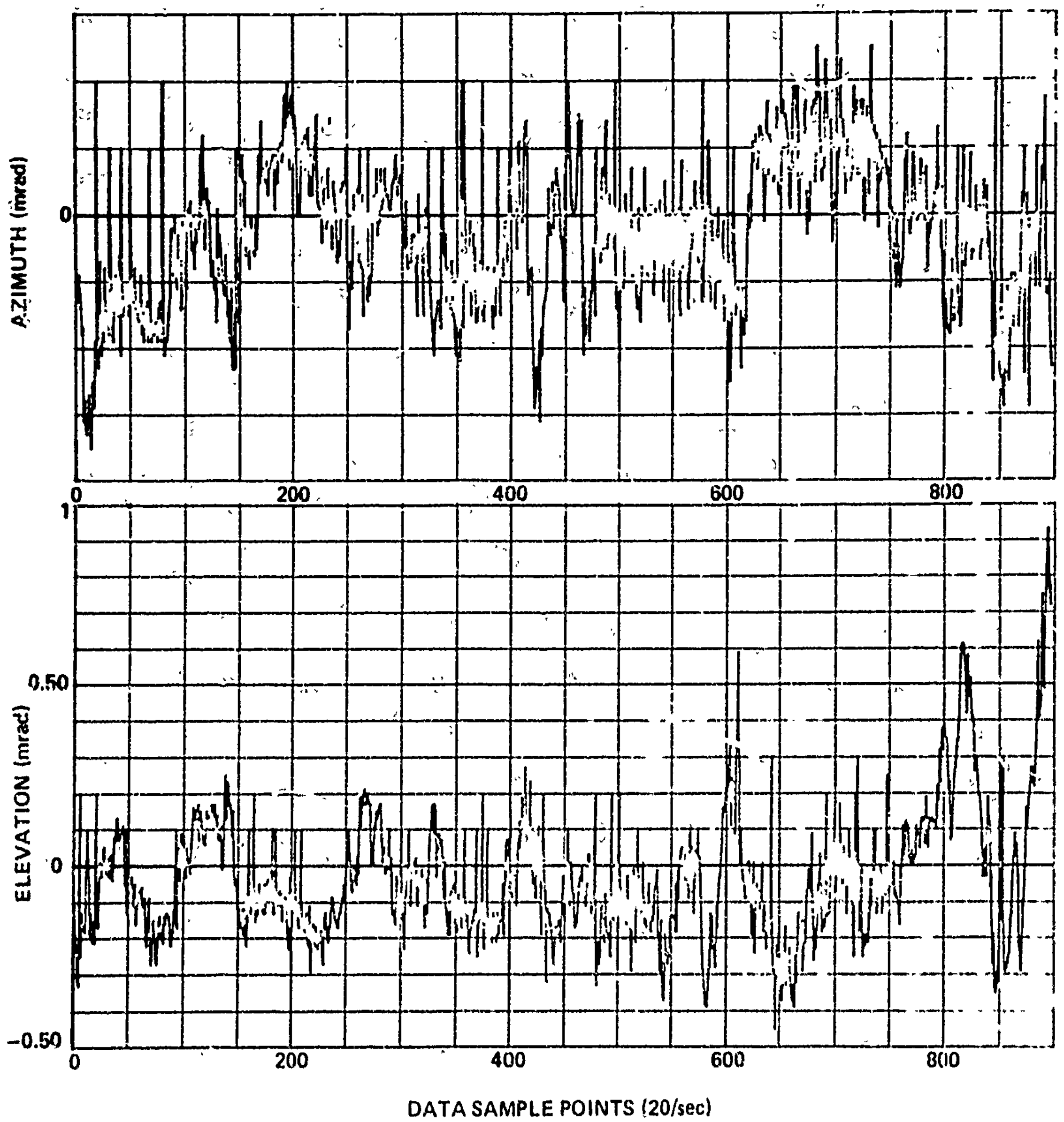
AZIMUTH (mrad)
10
0
0
200
400
600
800
ELEVATION (mrad)
0
−1
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

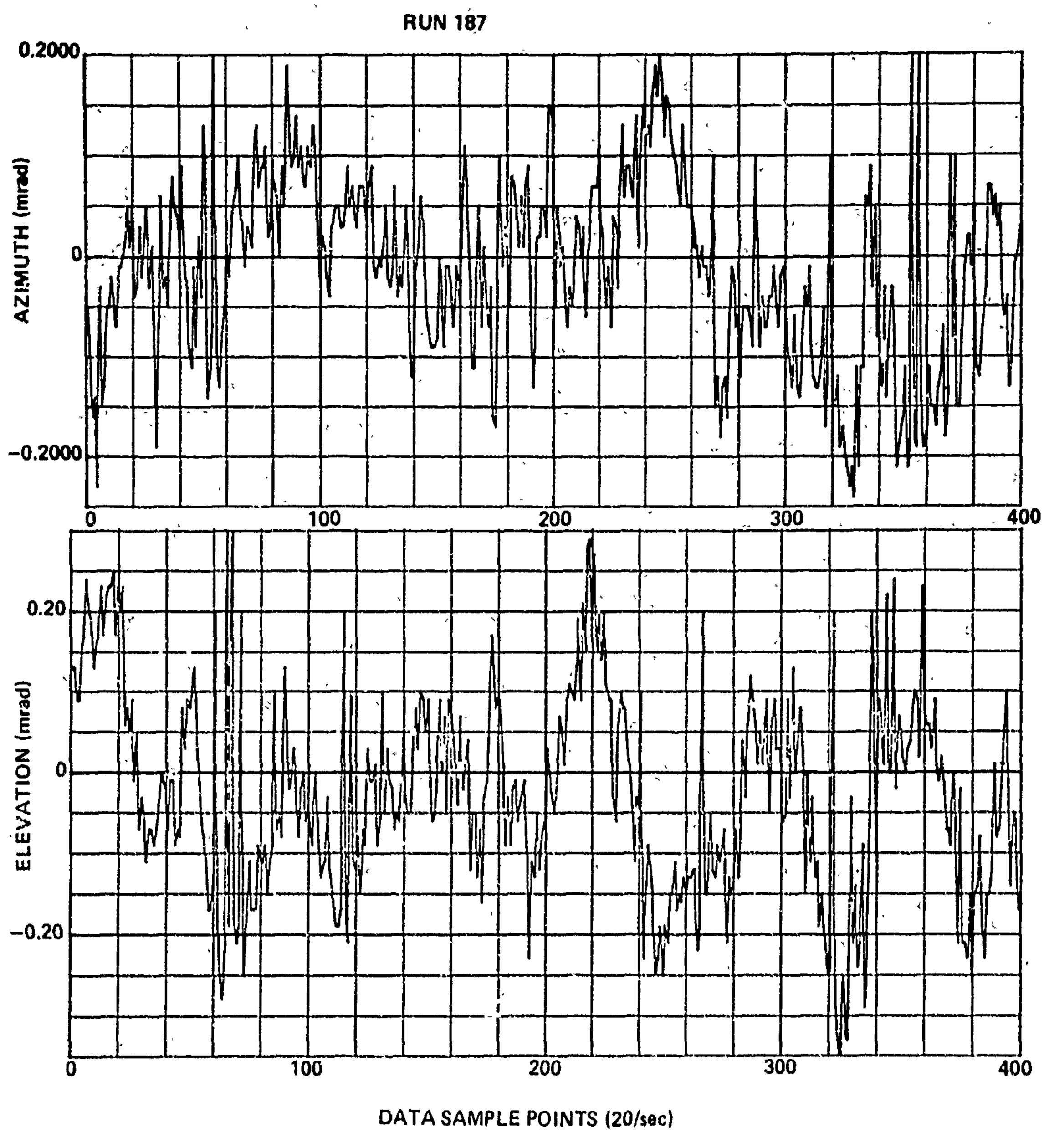


RUN 184
0.500
0
-0.500
AZIMUTH (mrad)
0
200
400
600
800
0.500
0
ELEVATION (mrad)
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

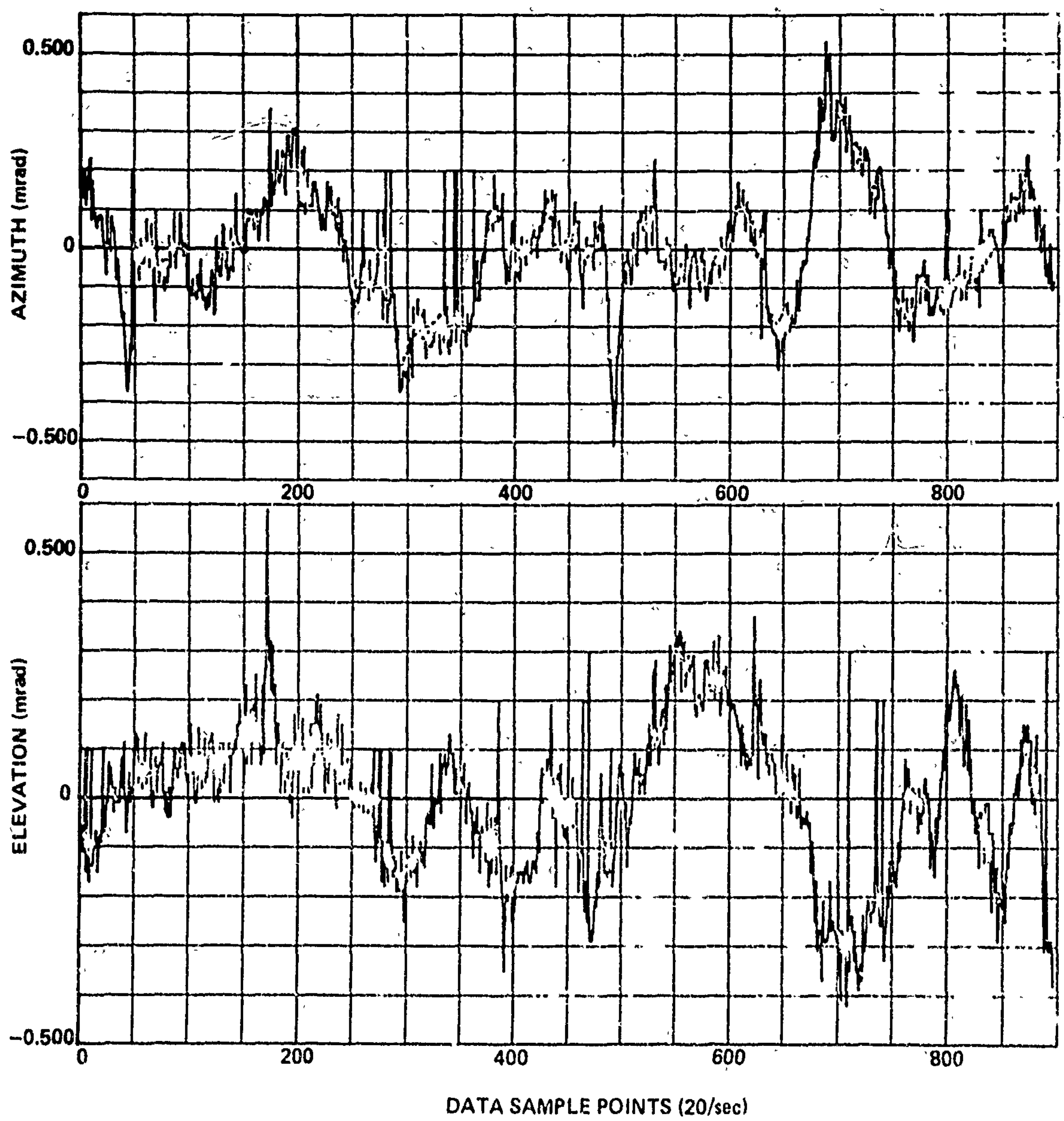

RUN 185
AZIMUTH (mrad)
ELEVATION (mrad)
0.500
0
-0.500
200
400
600
DATA SAMPLE POINTS (20/sec)

RUN 186

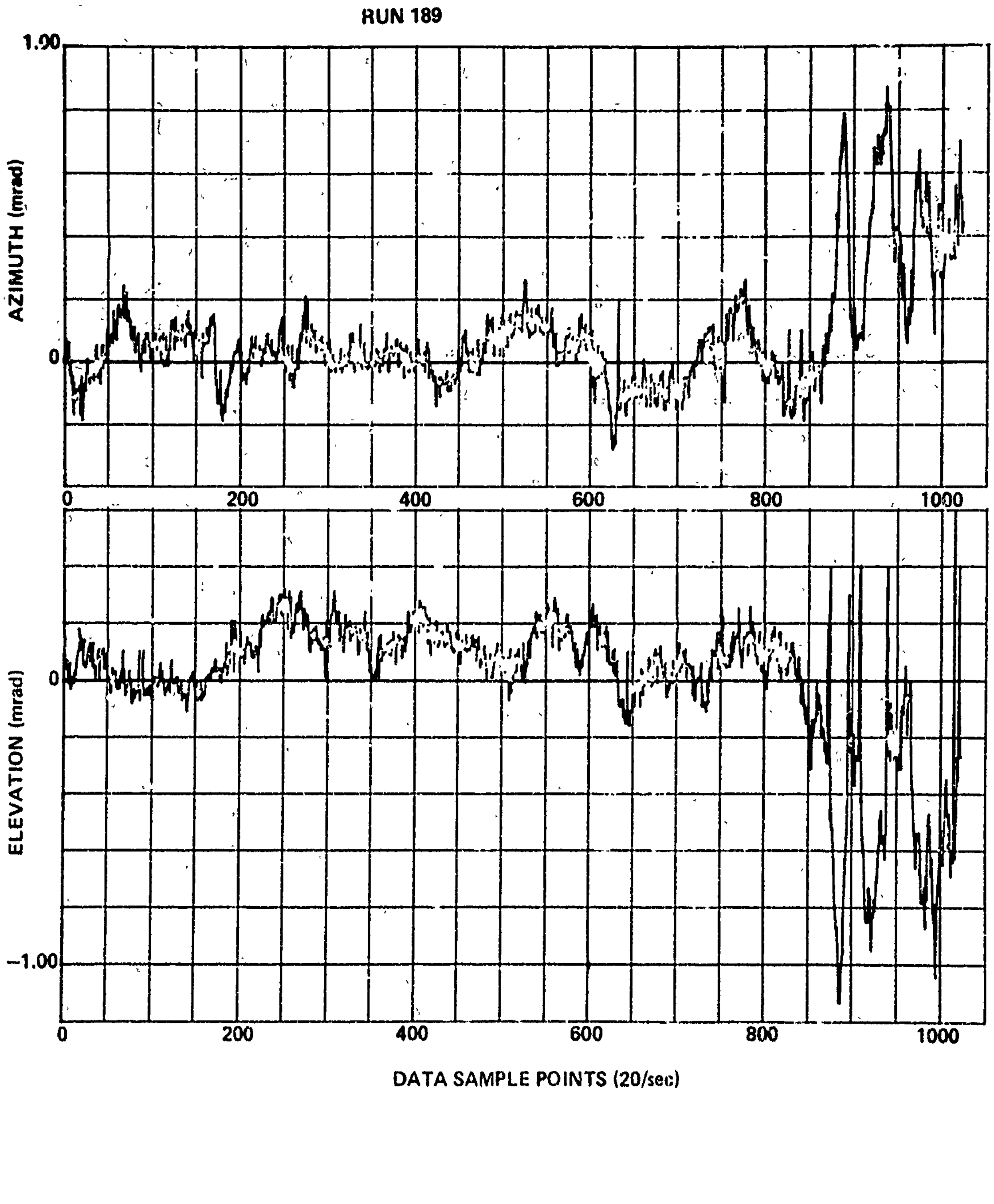

AZIMUTH (mrad)
0
0
200
400
600
800
ELEVATION (mrad)
1
0.50
0
-0.50
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

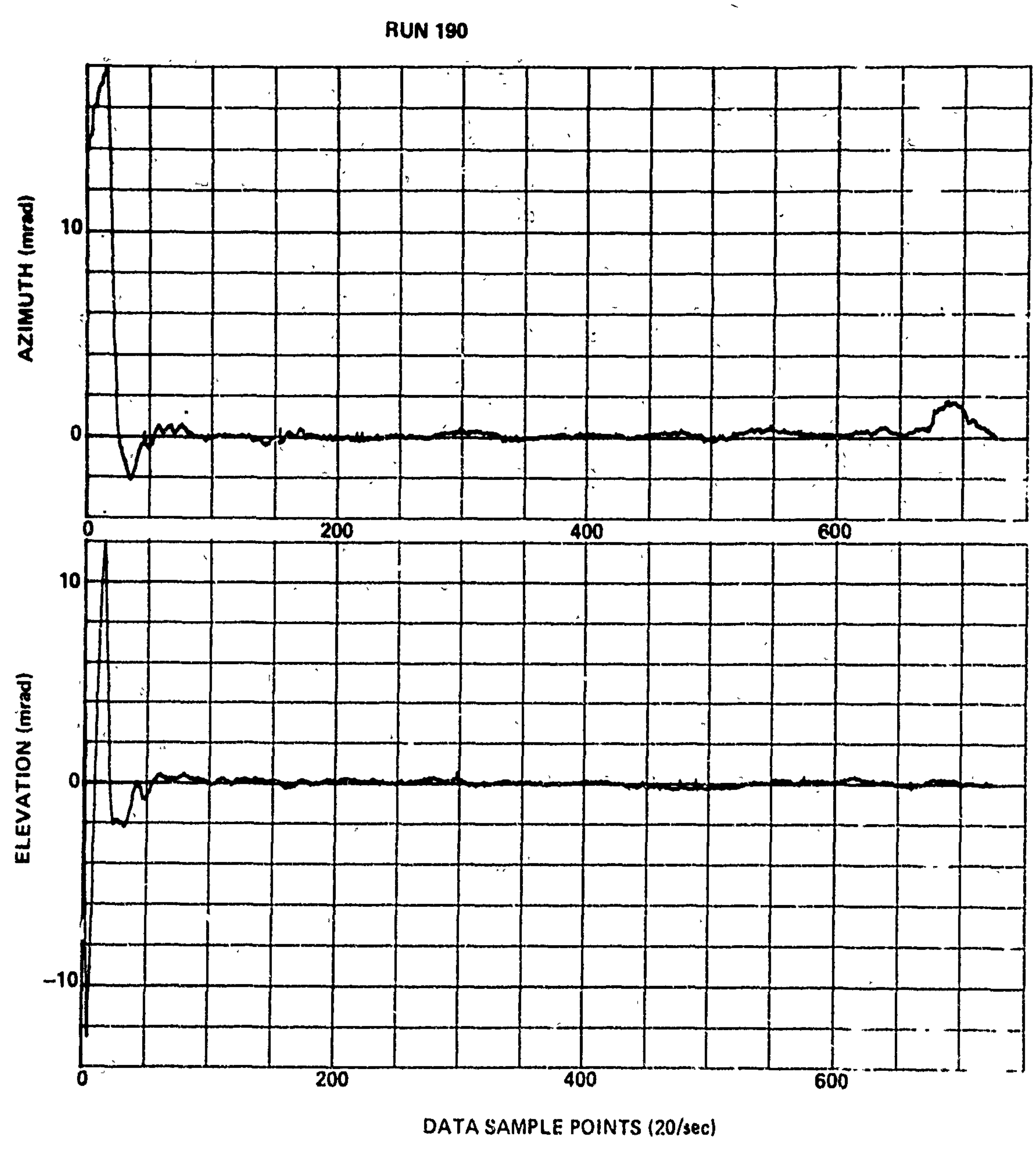

RUN 187
0.2000
0
-0.2000
AZIMUTH (mrad)
0
100
200
300
400
0.20
0
-0.20
ELEVATION (mrad)
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)

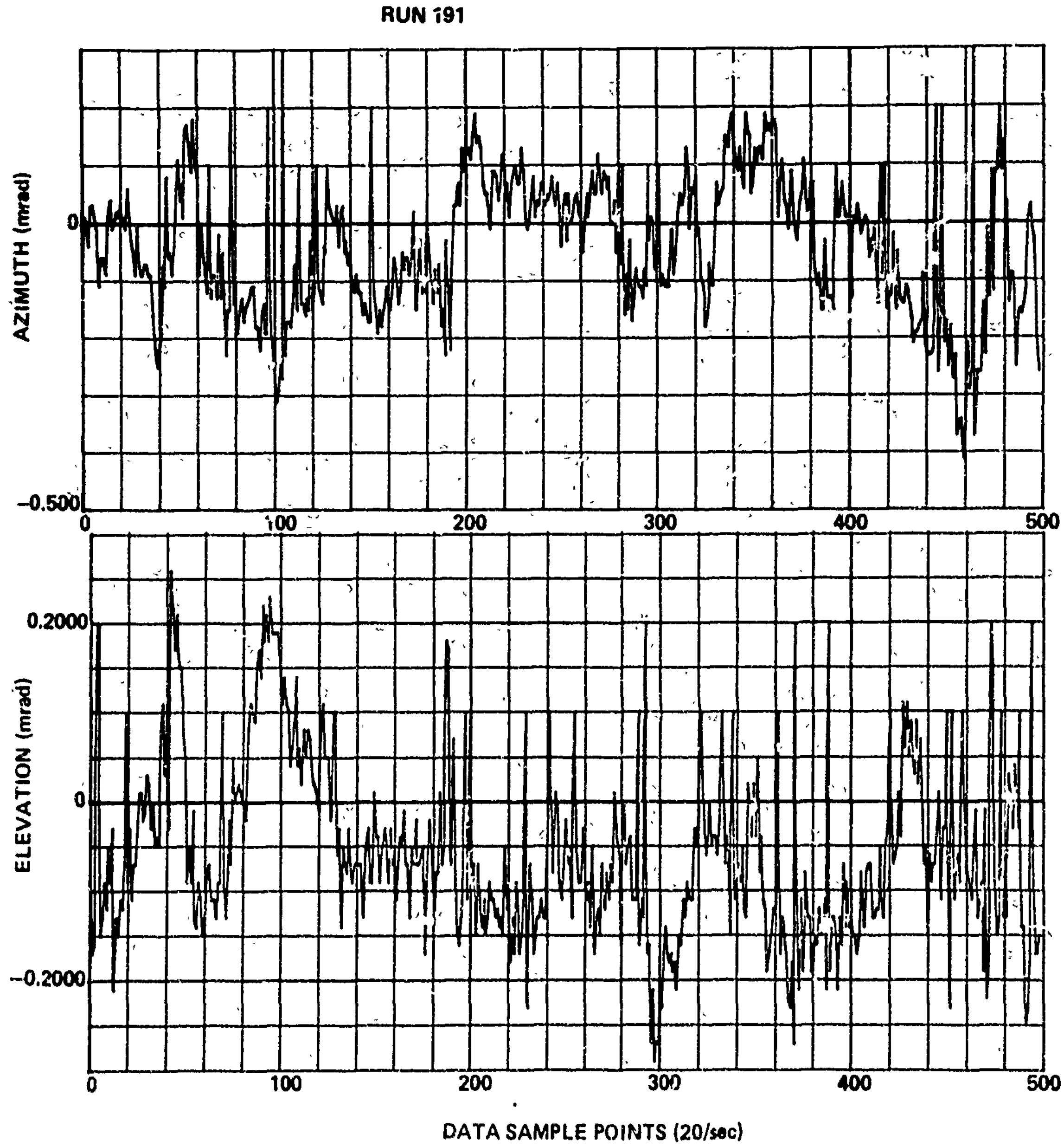
RUN 188

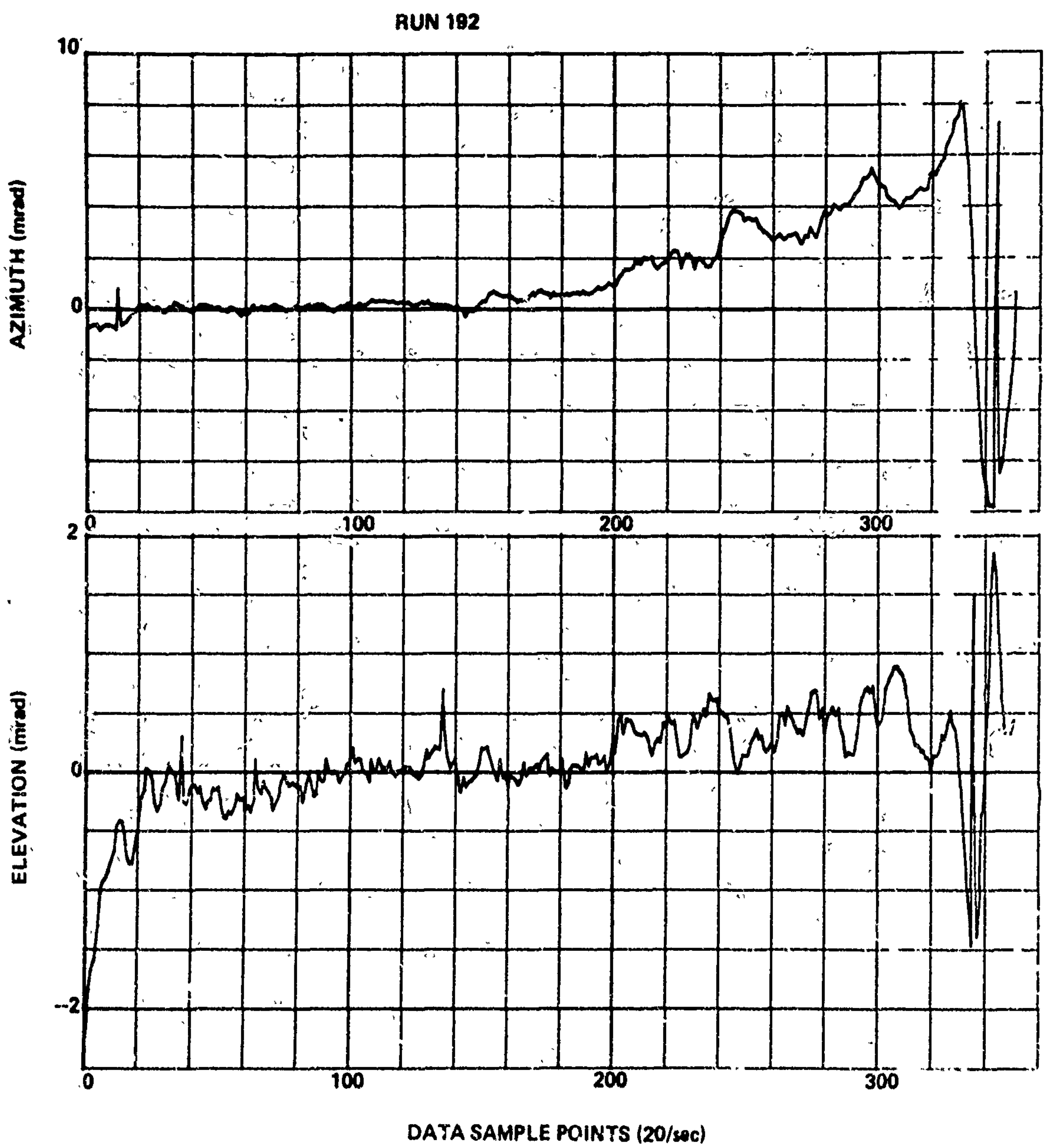


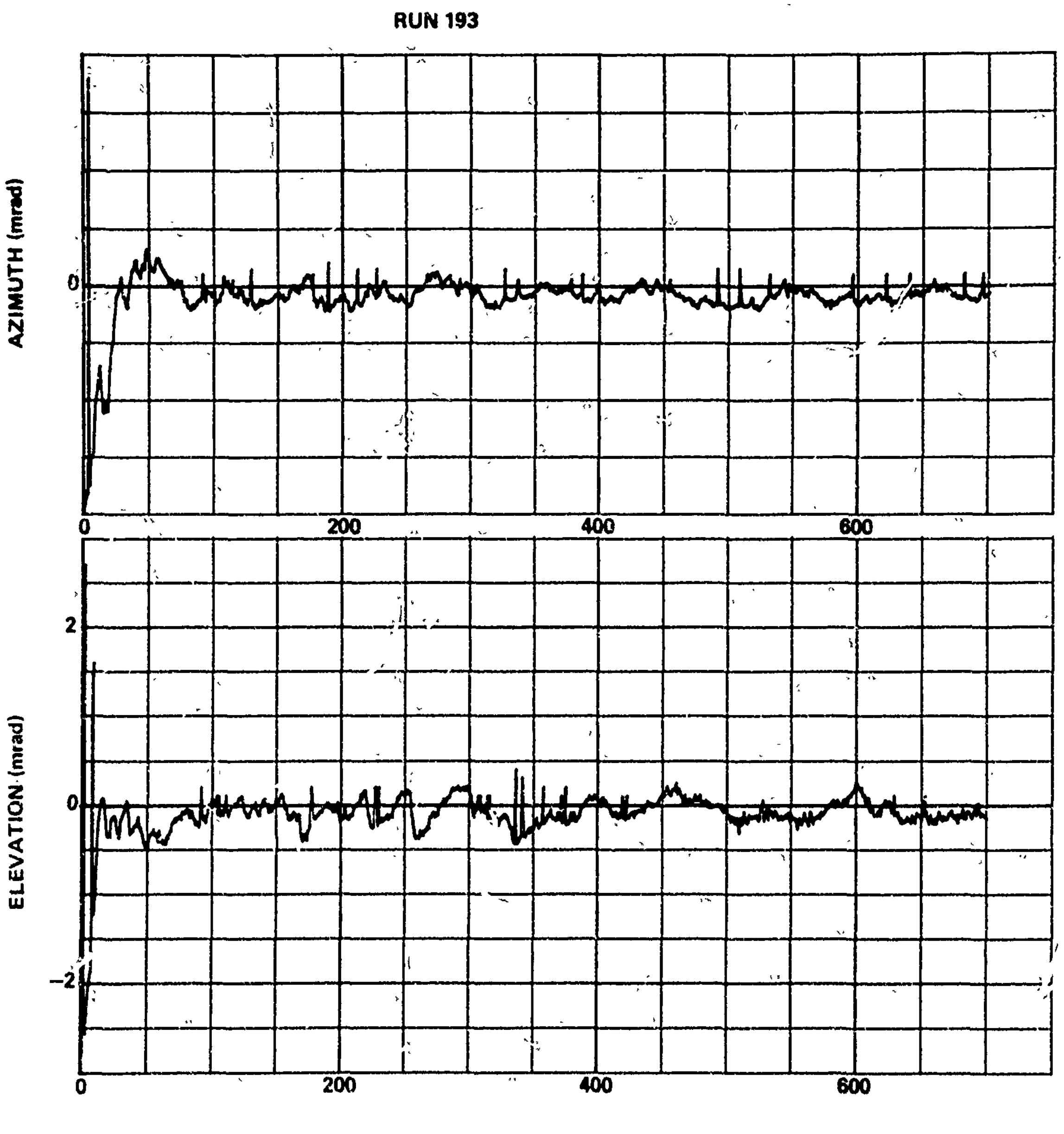
0.500
0
-0.500
AZIMUTH (mrad)
0
200
400
600
800
0.500
0
-0.500
ELEVATION (mrad)
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)


RUN 189
1.00
0
AZIMUTH (mrad)
0
200
400
600
800
1000
0
ELEVATION (mrad)
−1.00
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)

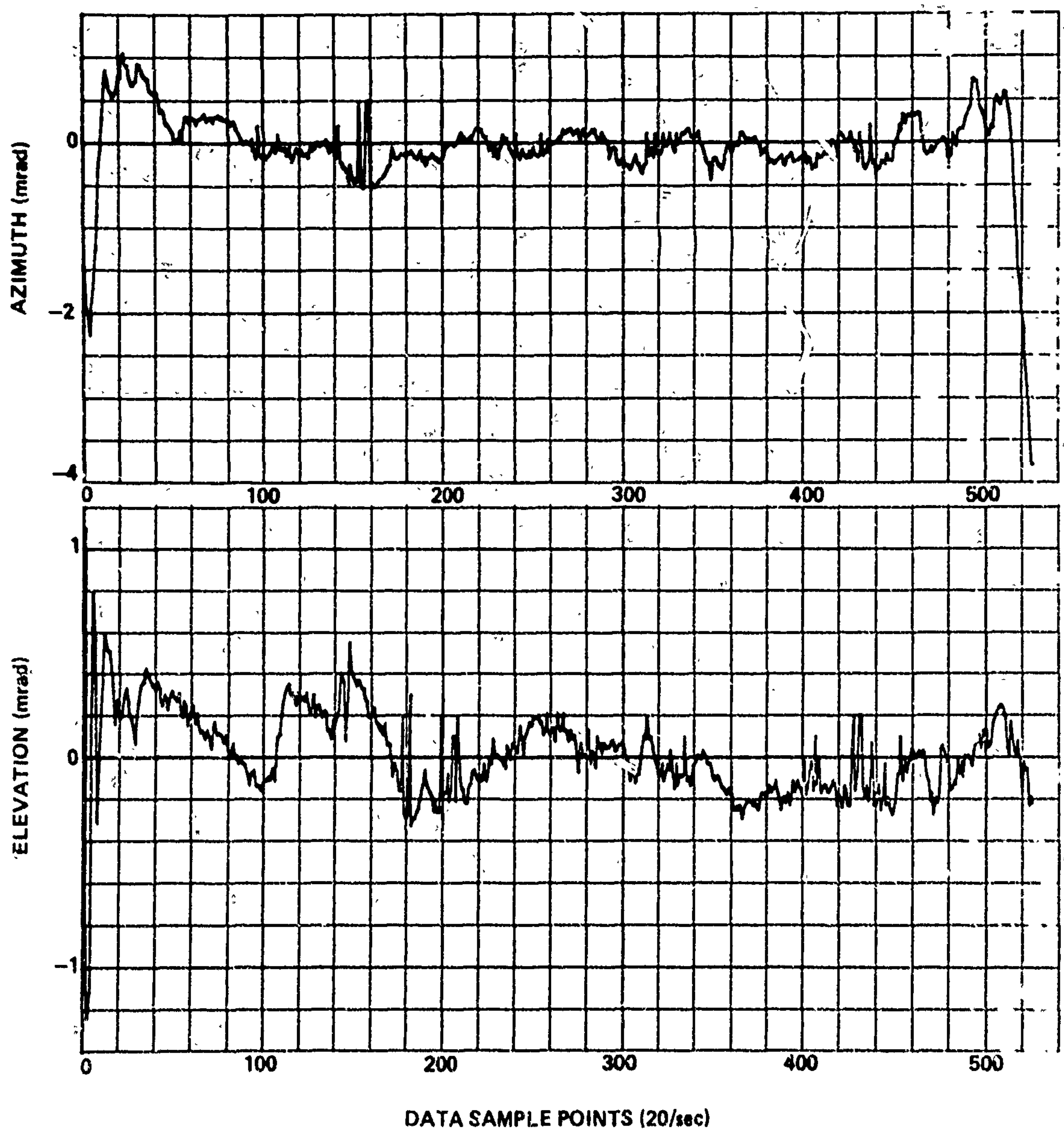

RUN 190
AZIMUTH (mrad)
10
0
0
200
400
600
ELEVATION (mrad)
10
0
–10
0
200
400
600
DATA SAMPLE POINTS (20/sec)


RUN 191
AZIMUTH (mrad)
0
-0.500
0
100
200
300
400
500
ELEVATION (mrad)
0.2000
0
-0.2000
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)


RUN 192
10
0
AZIMUTH (mrad)
0
100
200
300
2
0
-2
ELEVATION (mrad)
0
100
200
300
DATA SAMPLE POINTS (20/sec)

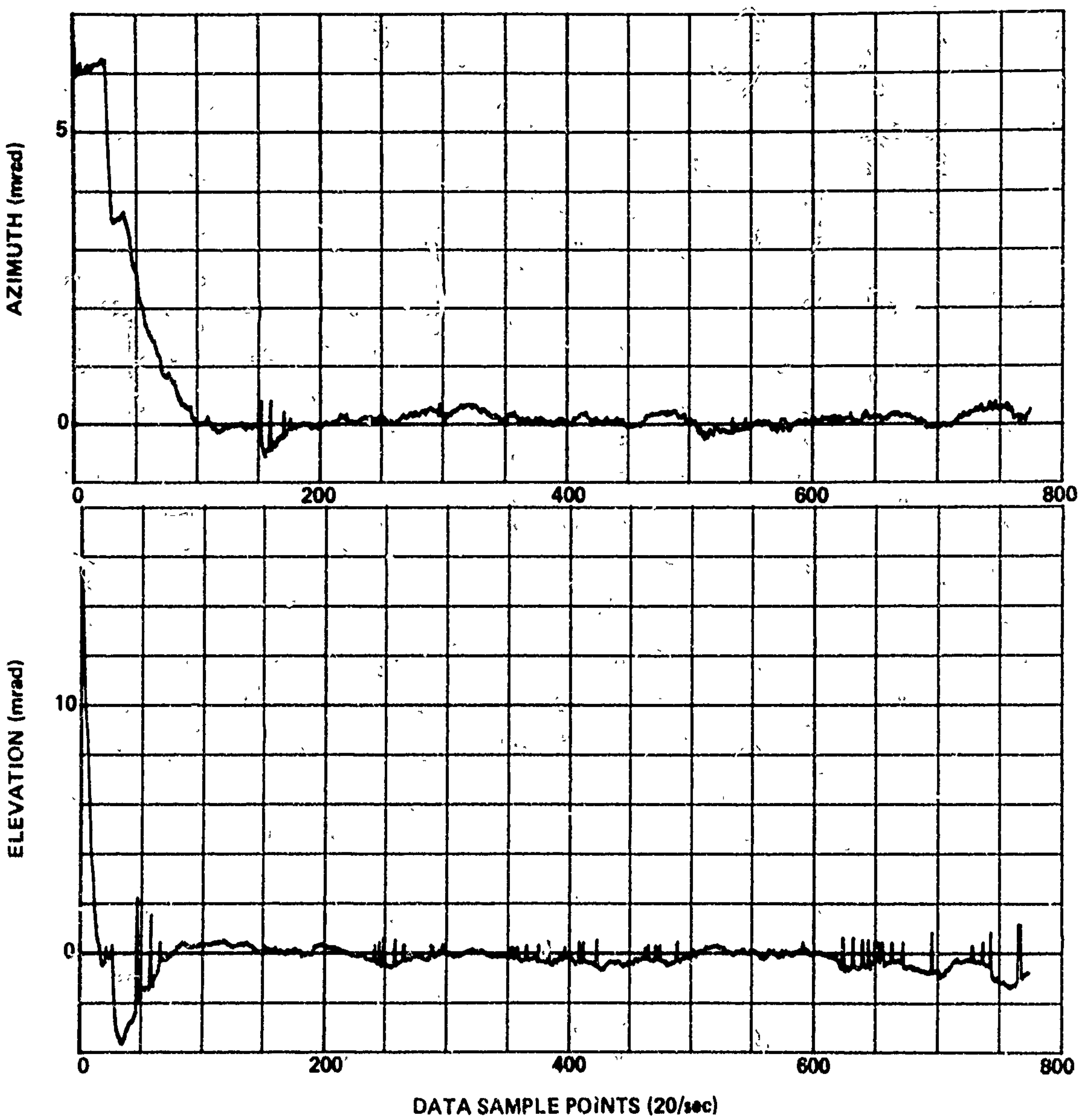

RUN 193
AZIMUTH (mrad)
0
0
200
400
600
ELEVATION (mrad)
2
0
−2
0
200
400
600
DATA SAMPLE POINTS (20/sec)

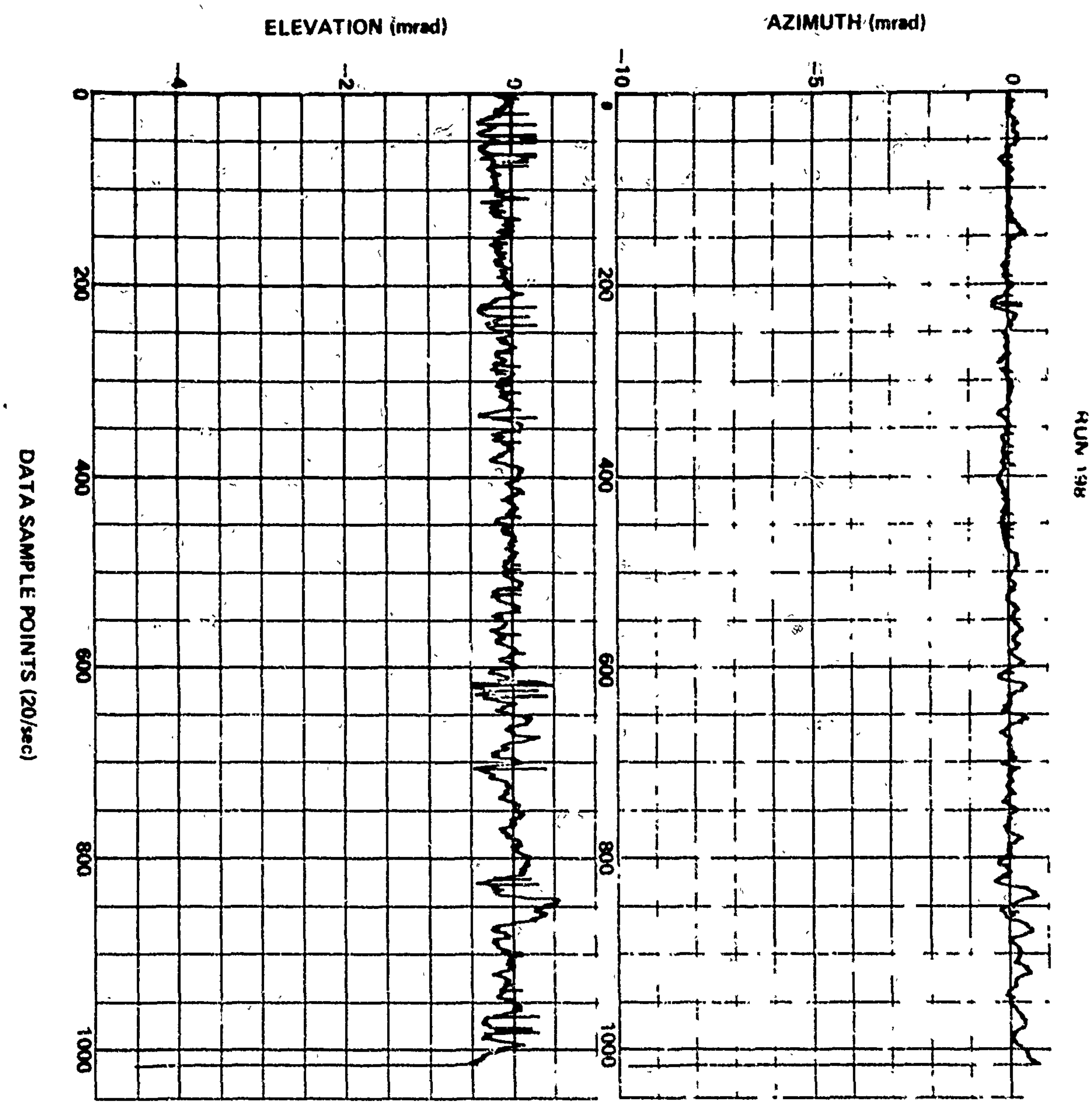
RUN 194

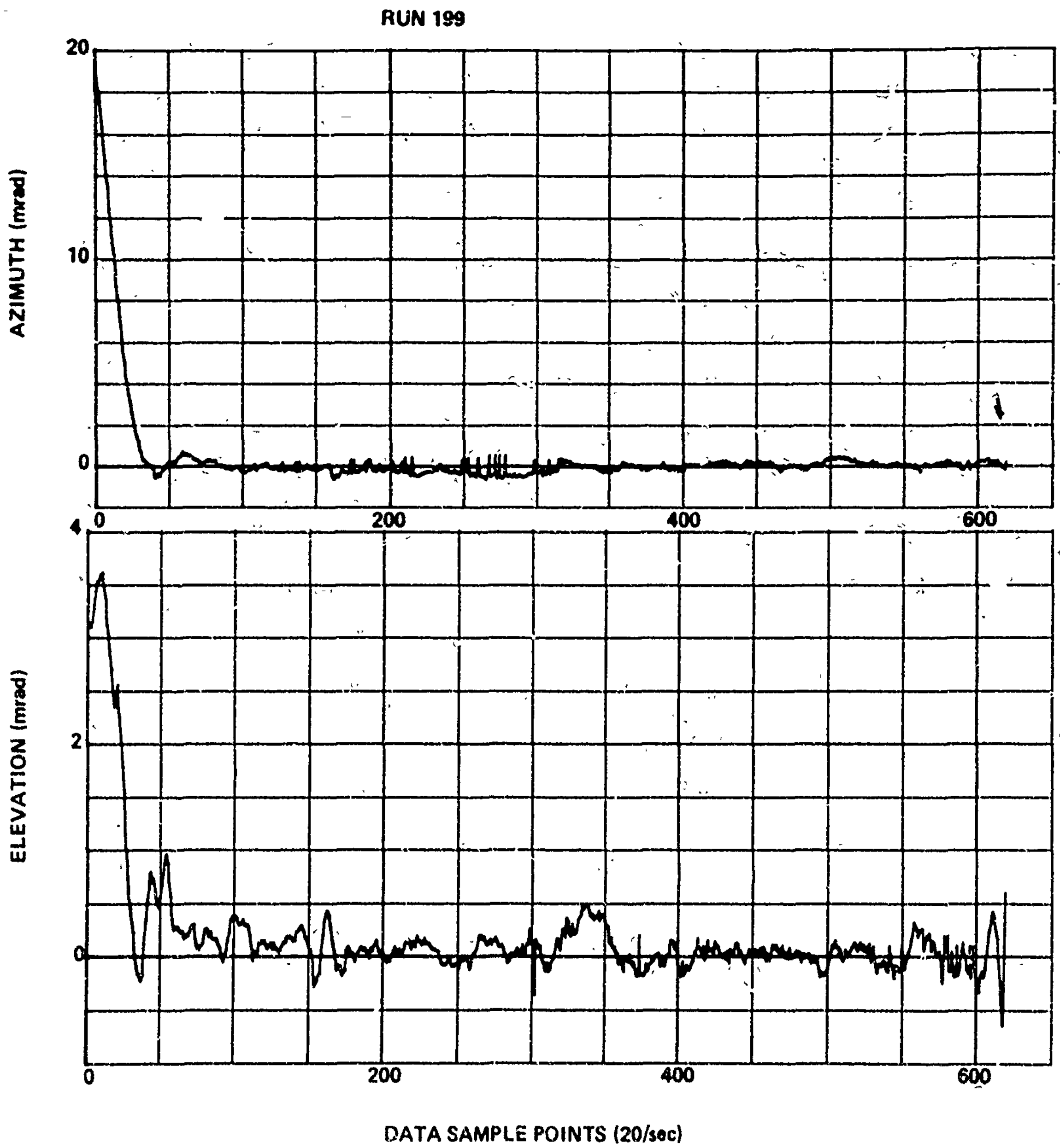


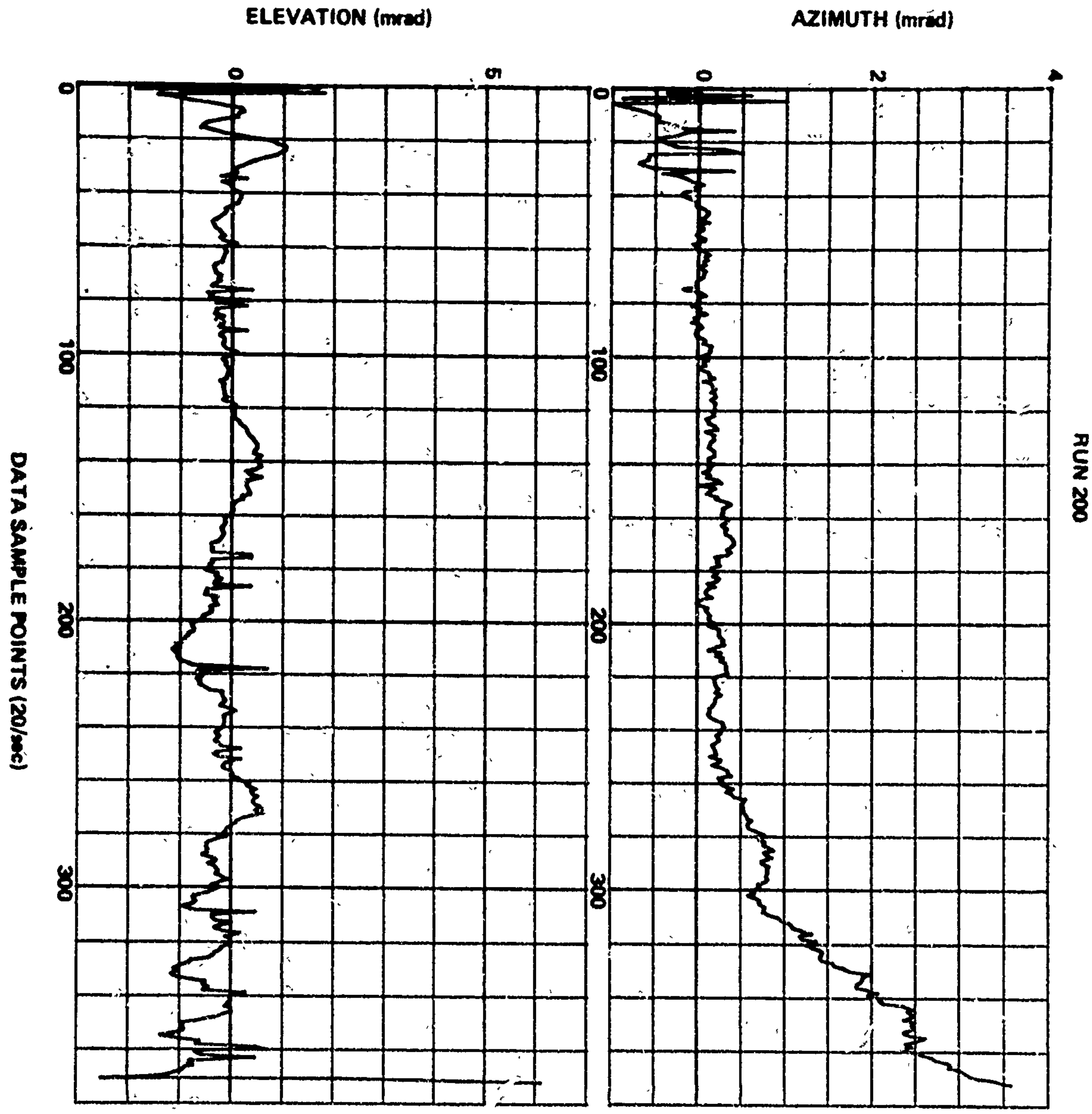
AZIMUTH (mrad)
0
-2
-4
0
100
200
300
400
500
ELEVATION (mrad)
1
0
-1
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

RUN 197.

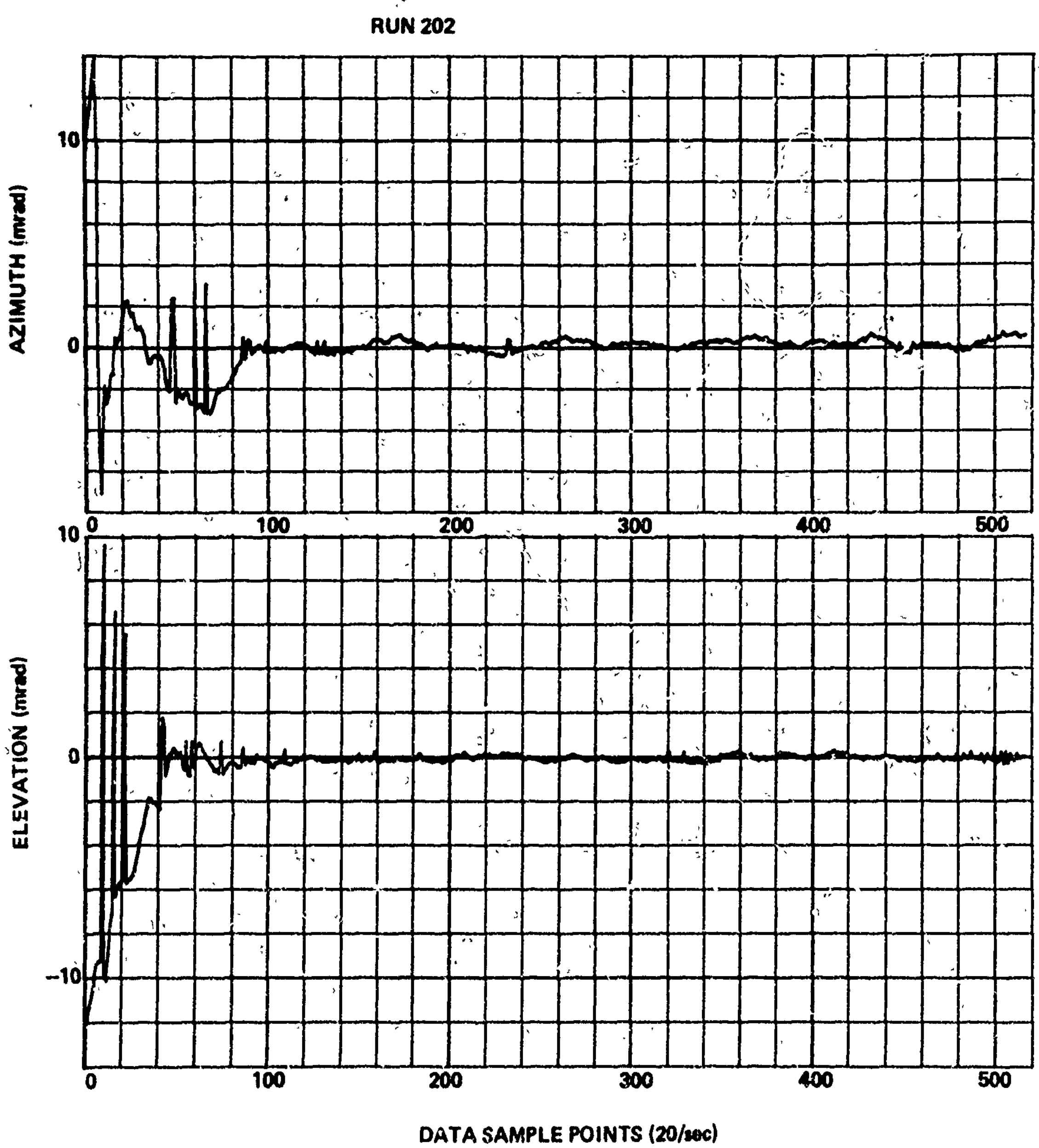

AZIMUTH (mrad)
5
0
0
200
400
600
800
ELEVATION (mrad)
10
0
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

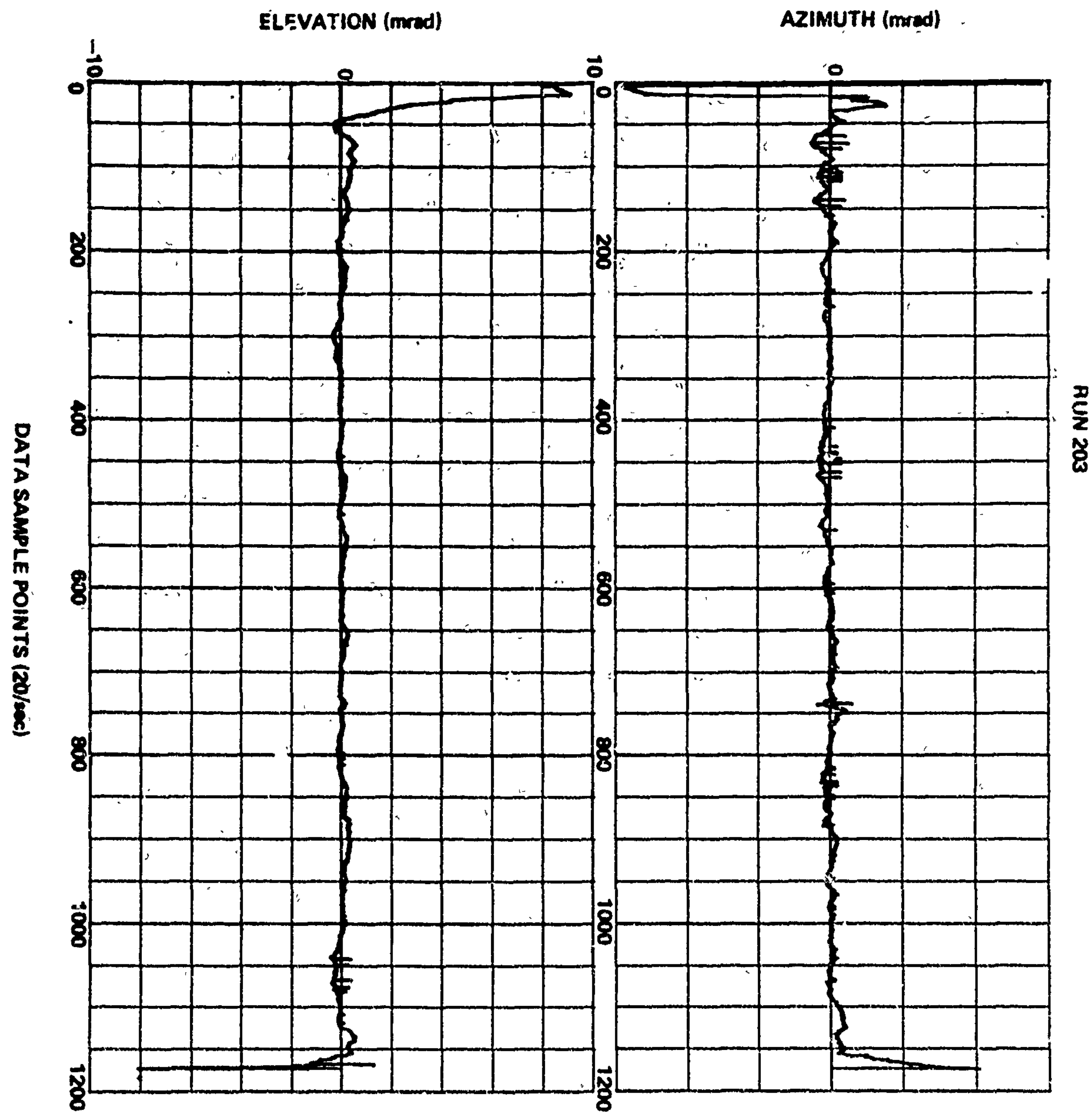

ELEVATION (mrad)
AZIMUTH (mrad)
RUN 198
DATA SAMPLE POINTS (20/sec)
-4
-2
0
-10
-5
0
200
400
600
800
1000

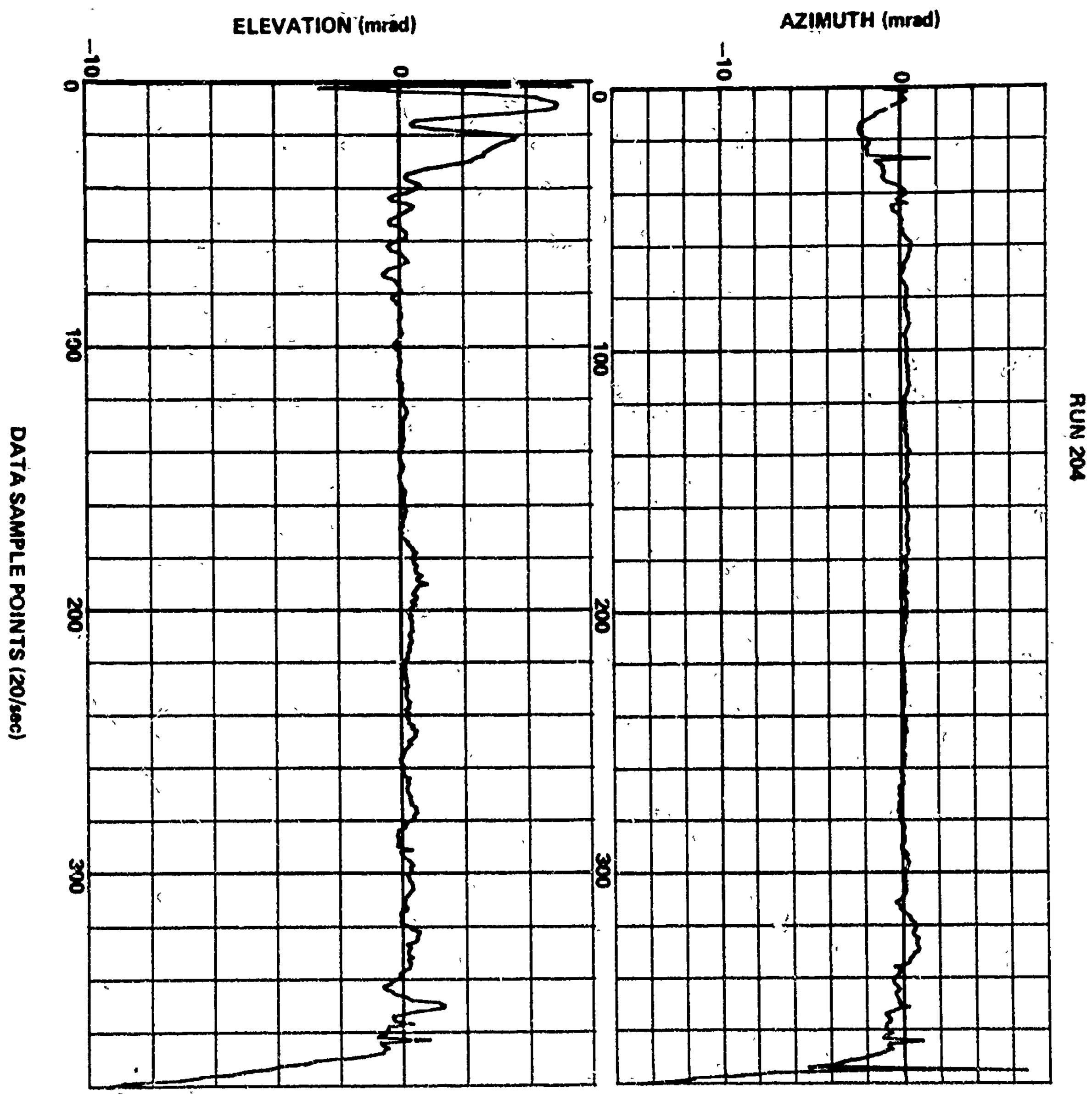

RUN 199
AZIMUTH (mrad)
20
10
0
0
200
400
600
ELEVATION (mrad)
4
2
0
0
200
400
600
DATA SAMPLE POINTS (20/sec)



ELEVATION (mrad)
AZIMUTH (mrad)
RUN 200
DATA SAMPLE POINTS (20/sec)
0
5
0
2
4
0
100
200
300

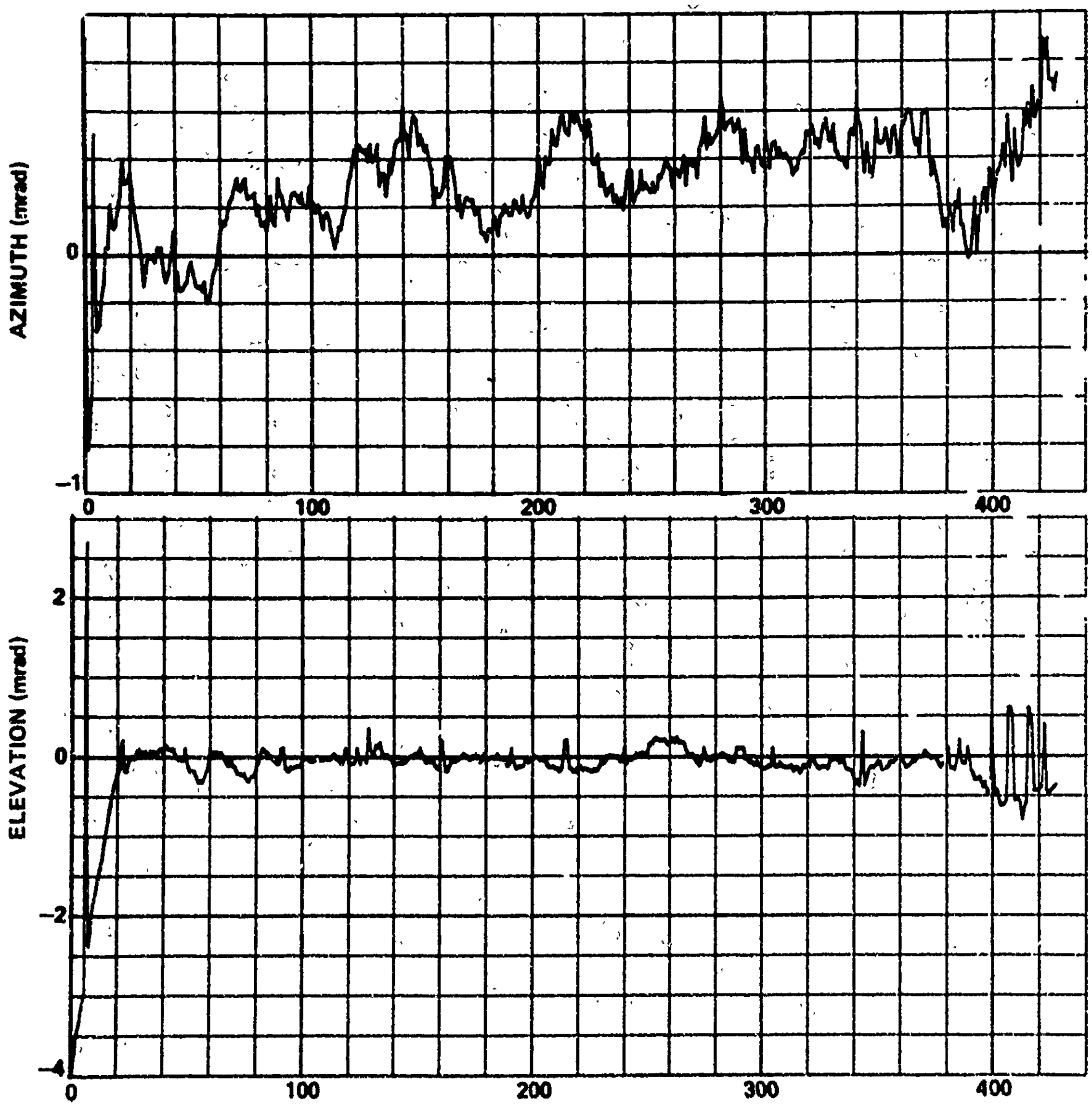

RUN 202
AZIMUTH (mrad)
10
0
0
100
200
300
400
500
ELEVATION (mrad)
10
0
-10
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)


ELEVATION (mrad)
AZIMUTH (mrad)
RUN 203
DATA SAMPLE POINTS (20/sec)
-10
0
10
0
200
400
600
800
1000
1200

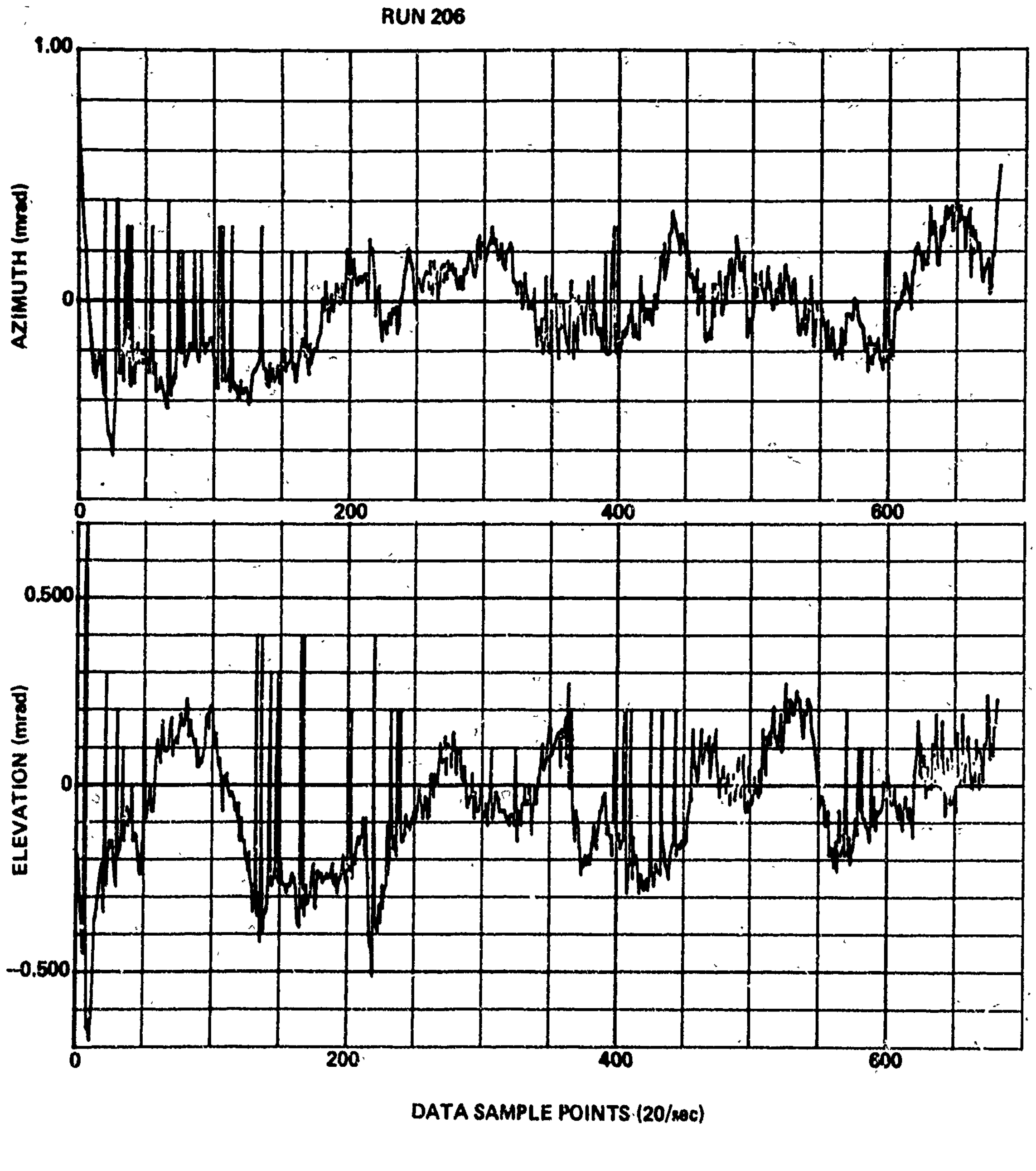


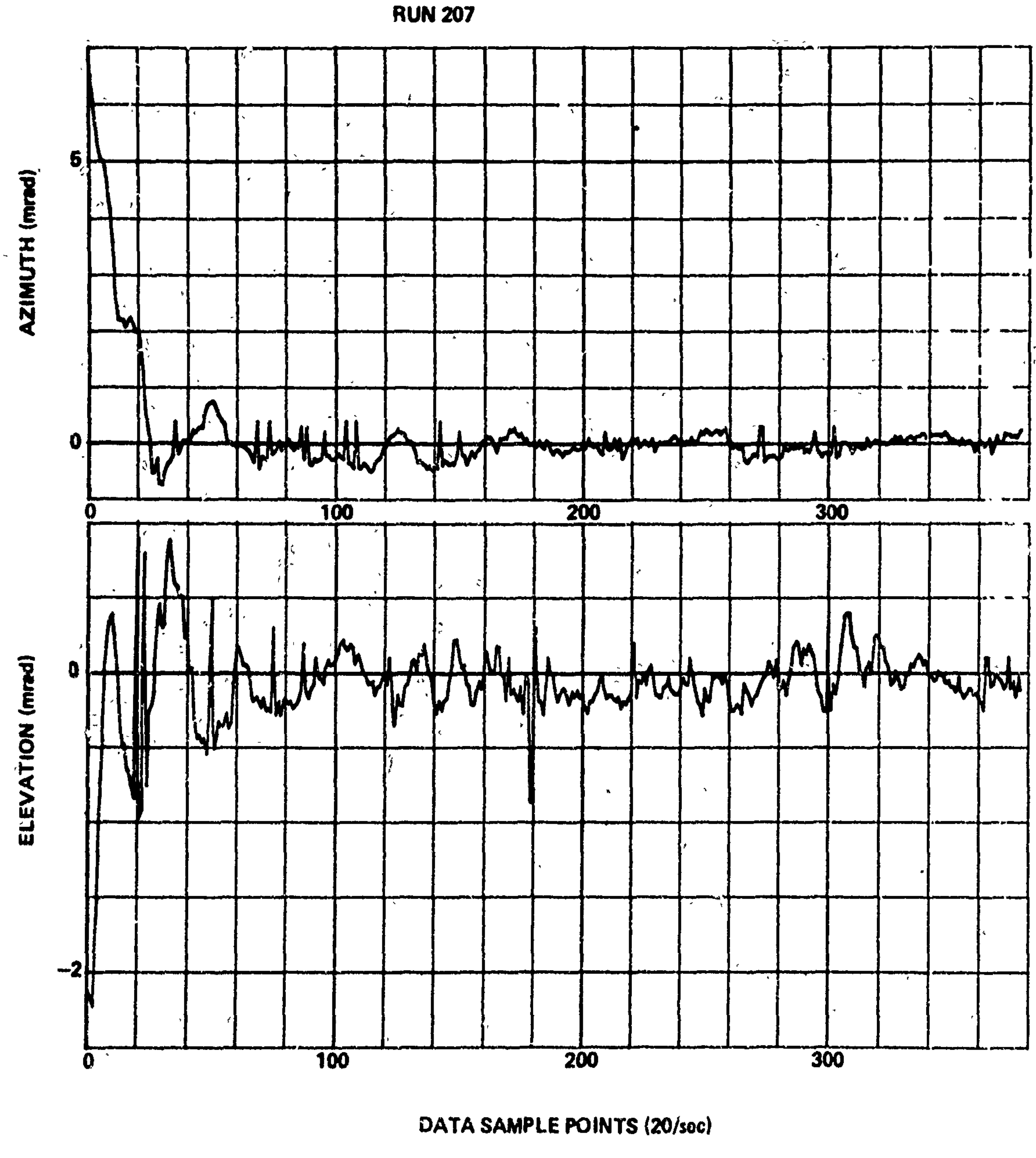
RUN 204
ELEVATION (mrad)
AZIMUTH (mrad)
−10
0
100
200
300
DATA SAMPLE POINTS (20/sec)

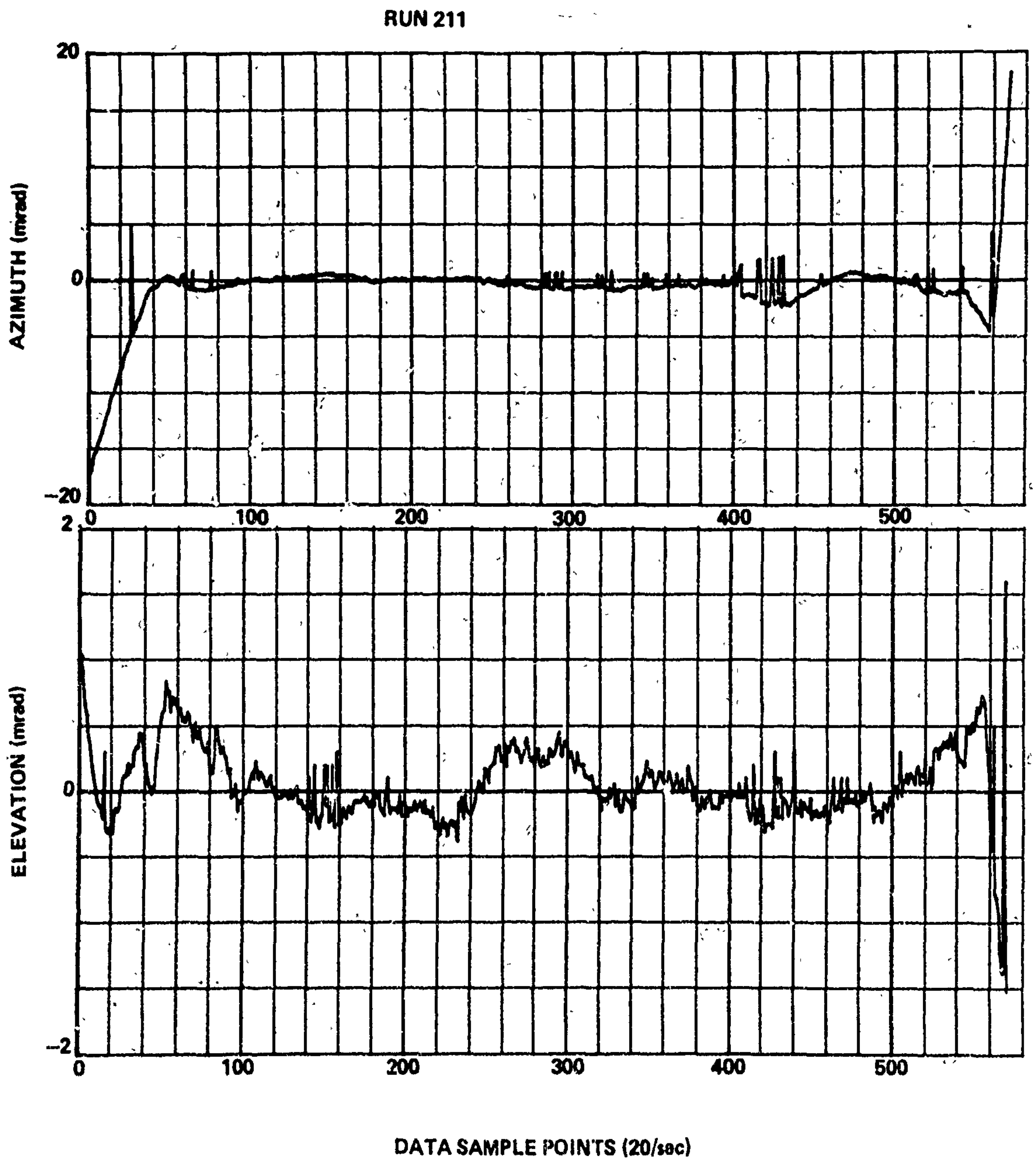
RUN 205



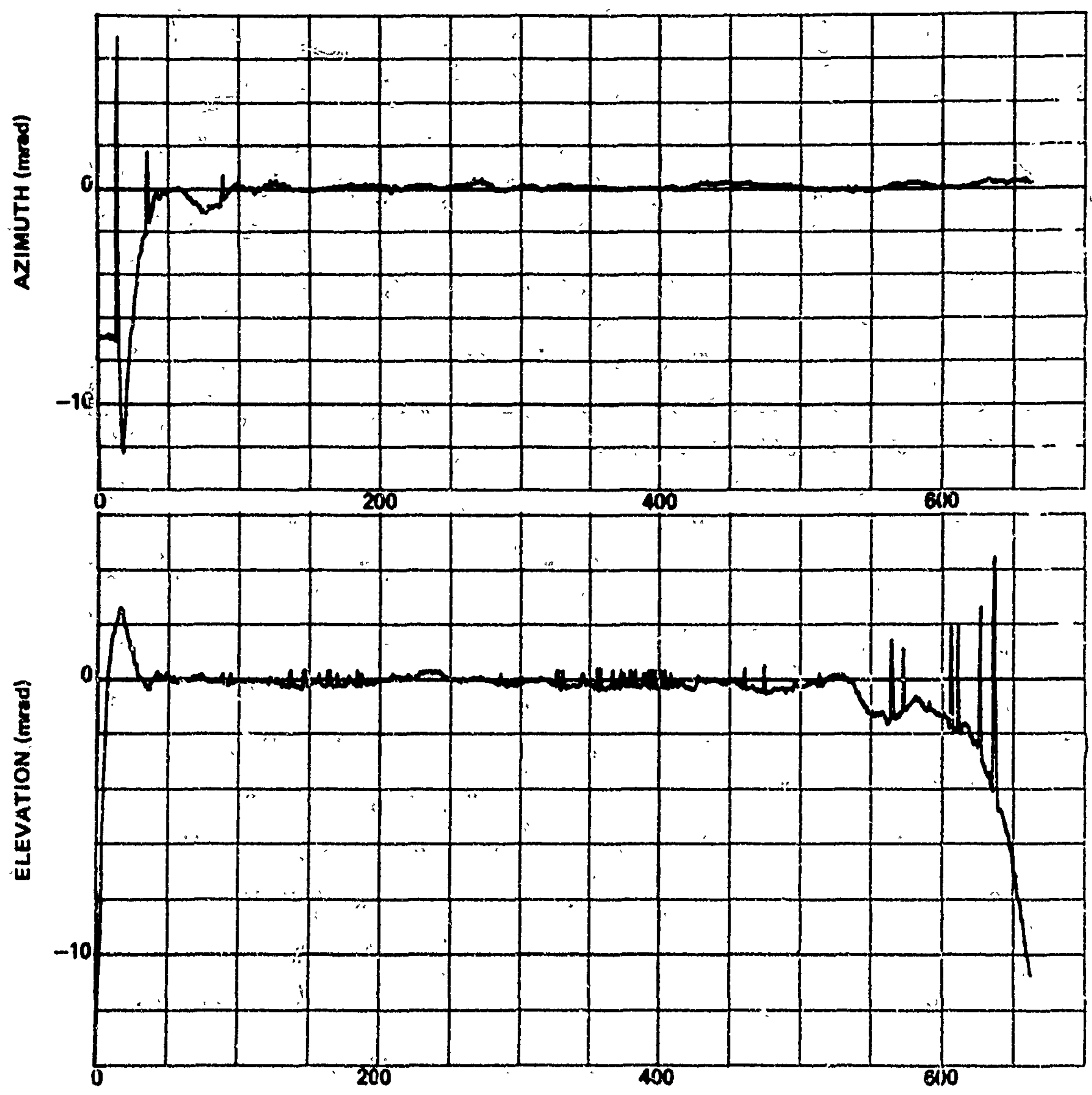
DATA SAMPLE POINTS (20/sec)


RUN 206
1.00
0
AZIMUTH (mrad)
0
200
400
600
0.500
0
-0.500
ELEVATION (mrad)
0
200
400
600
DATA SAMPLE POINTS (20/sec)

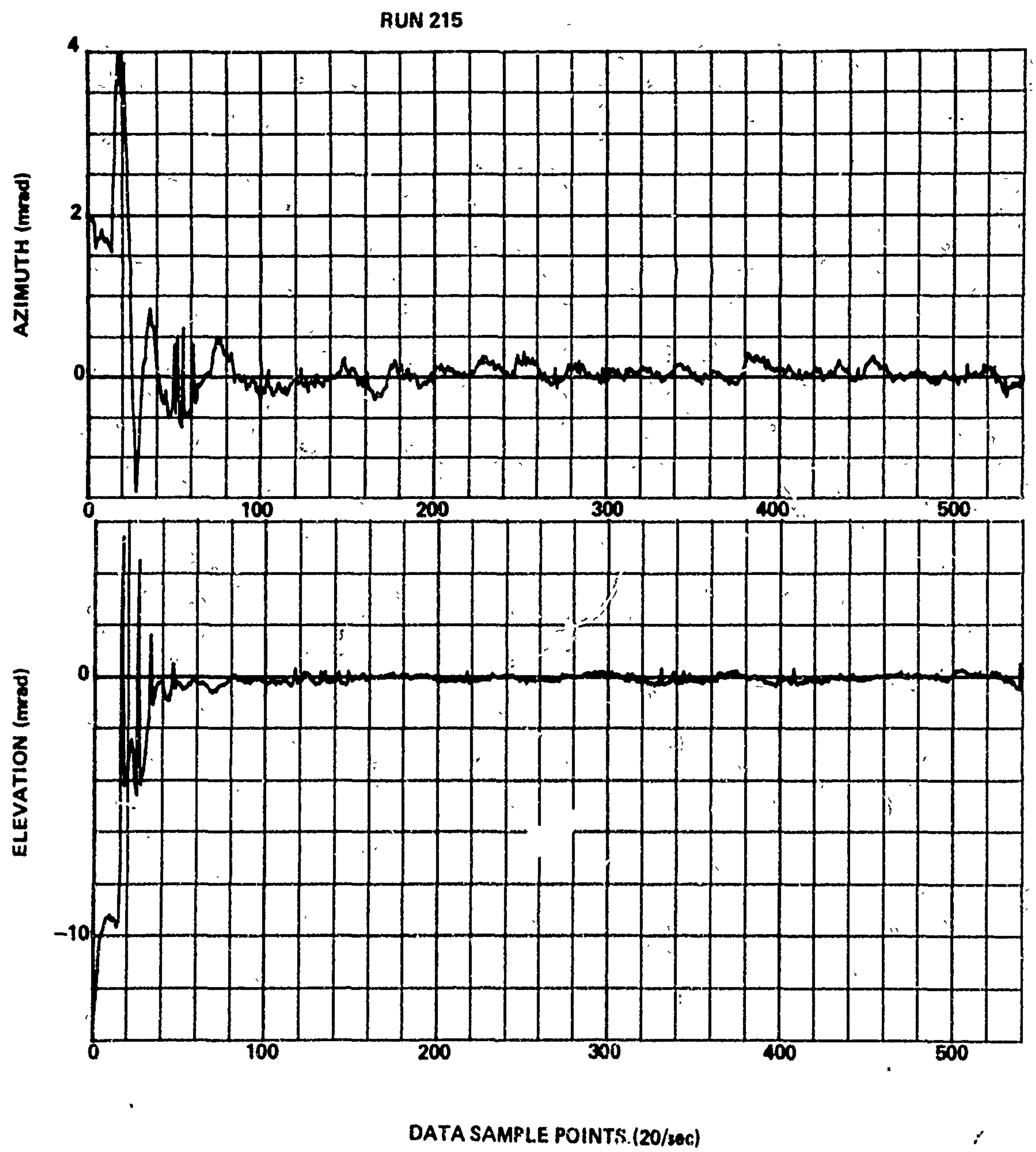

RUN 207
AZIMUTH (mrad)
5
0
100
200
300
ELEVATION (mrad)
0
-2
0
100
200
300
DATA SAMPLE POINTS (20/sec)

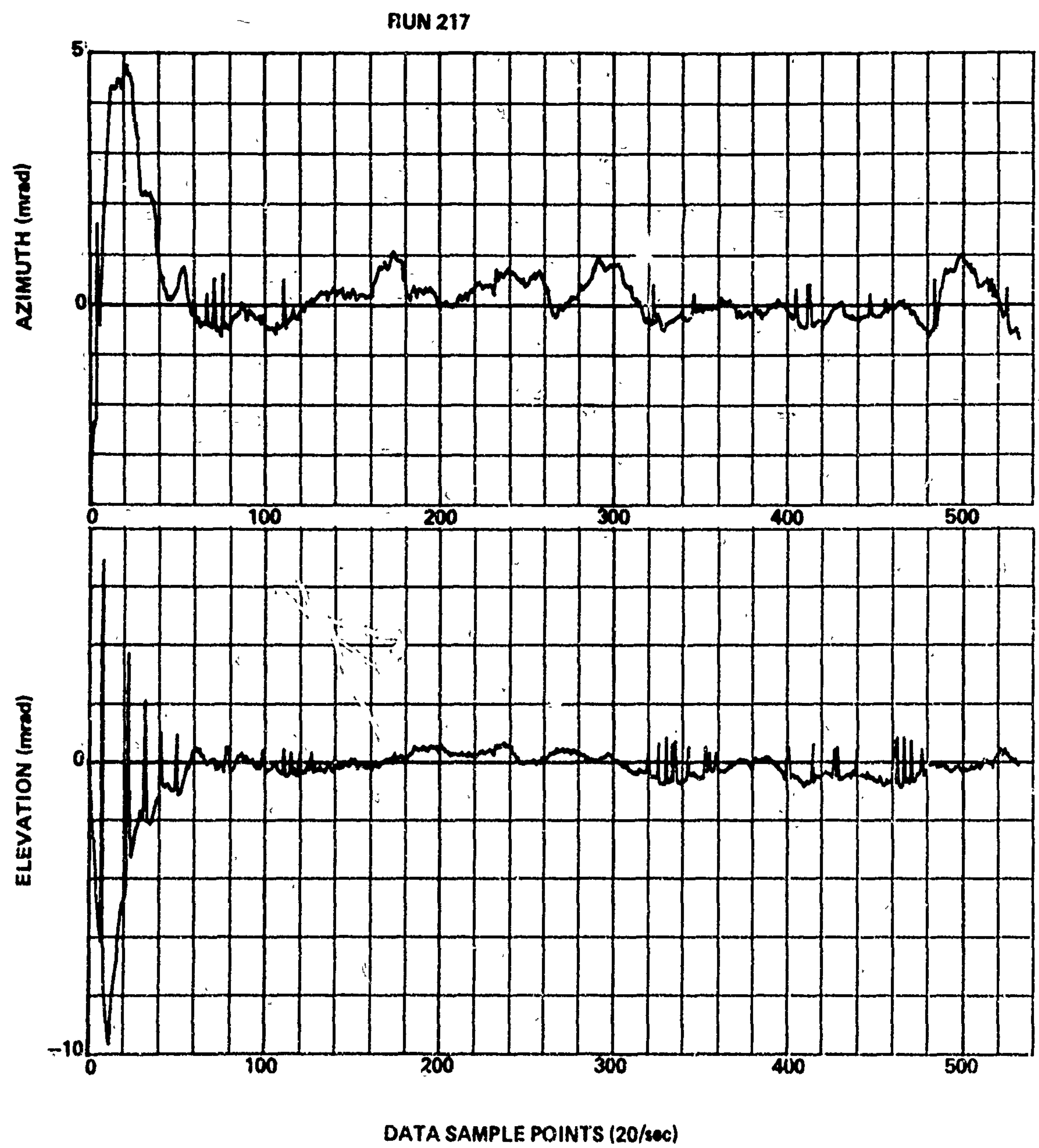

RUN 211
AZIMUTH (mrad)
20
0
-20
ELEVATION (mrad)
2
0
-2
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

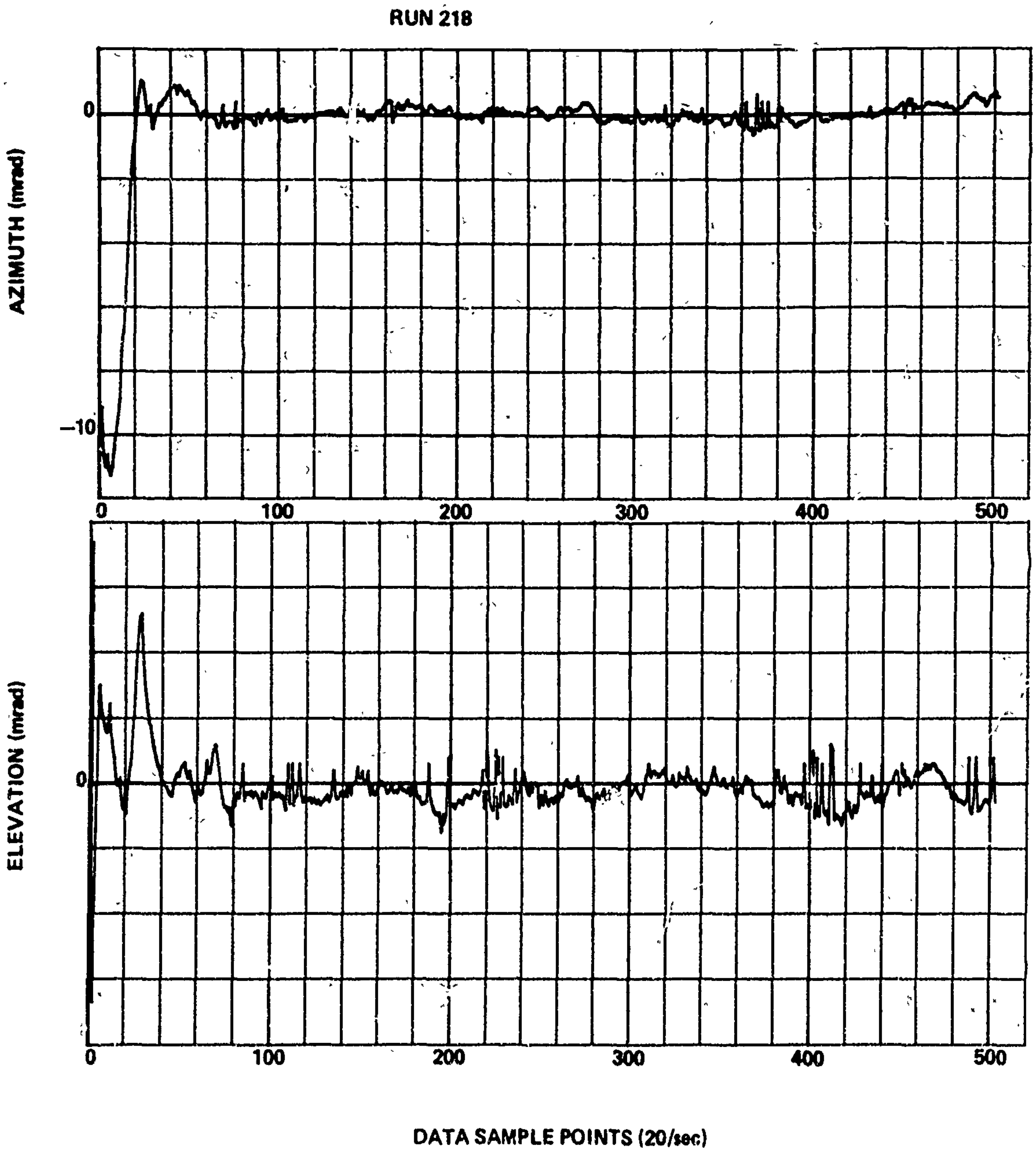
RUN 214



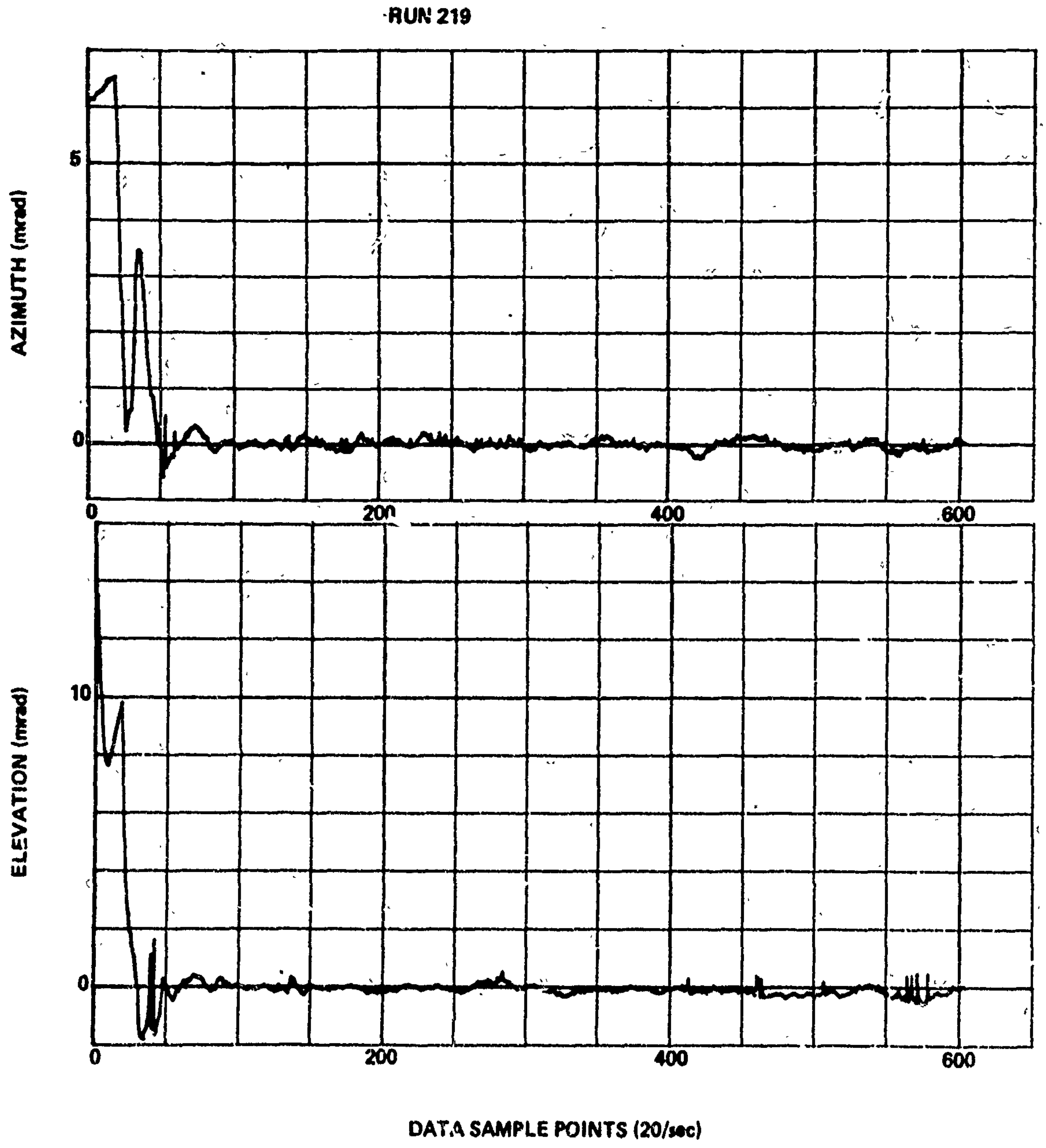
DATA SAMPLE POINTS (20/sec)

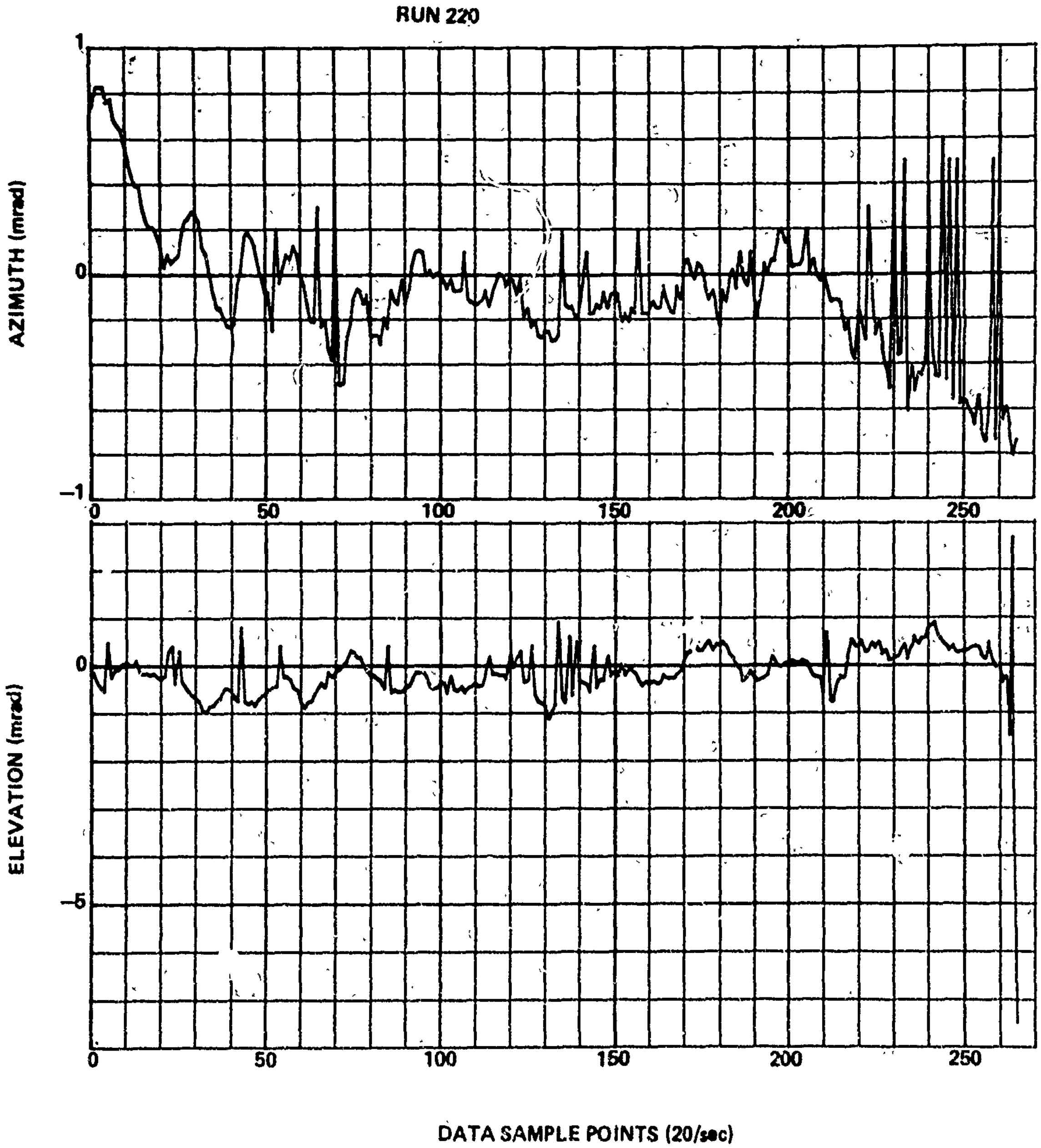

RUN 215
AZIMUTH (mrad)
4
2
0
0
100
200
300
400
500
ELEVATION (mrad)
0
-10
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)


RUN 217
AZIMUTH (mrad)
5
0
0
100
200
300
400
500
ELEVATION (mrad)
0
-10
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

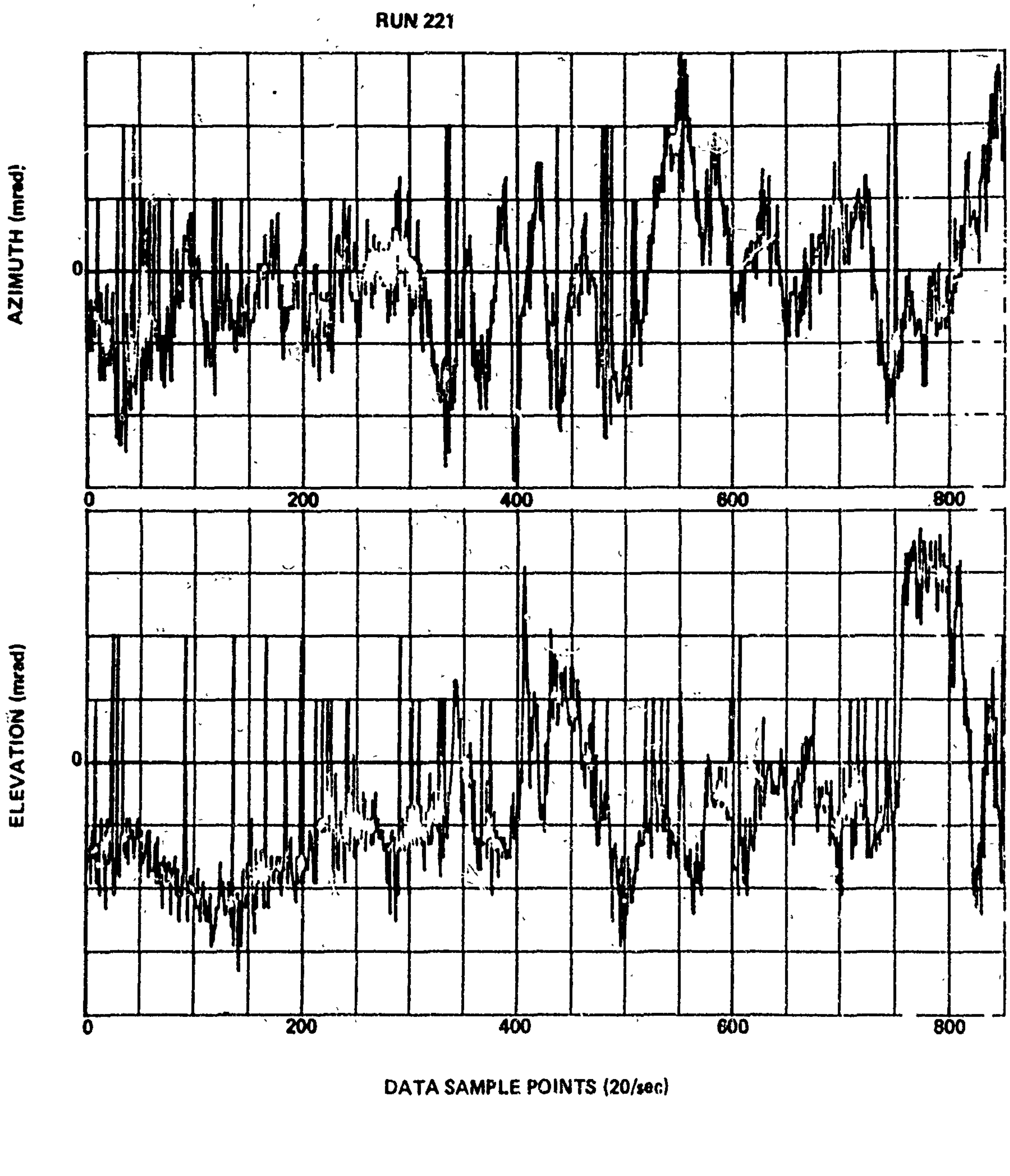


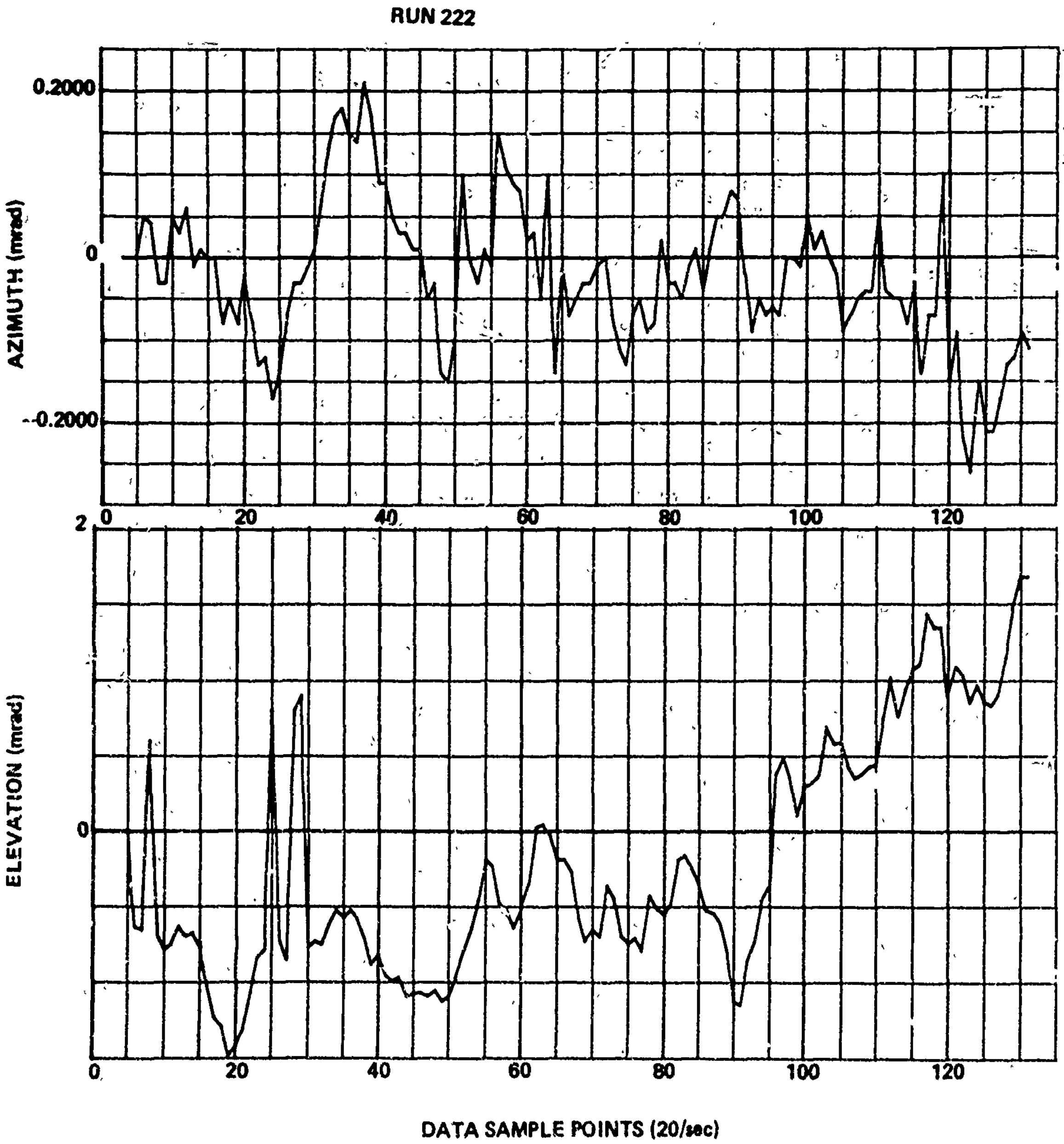
RUN 218
AZIMUTH (mrad)
0
−10
0
100
200
300
400
500
ELEVATION (mrad)
0
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)


RUN 219
AZIMUTH (mrad)
5
0
0
200
400
600
ELEVATION (mrad)
10
0
0
200
400
600
DATA SAMPLE POINTS (20/sec)

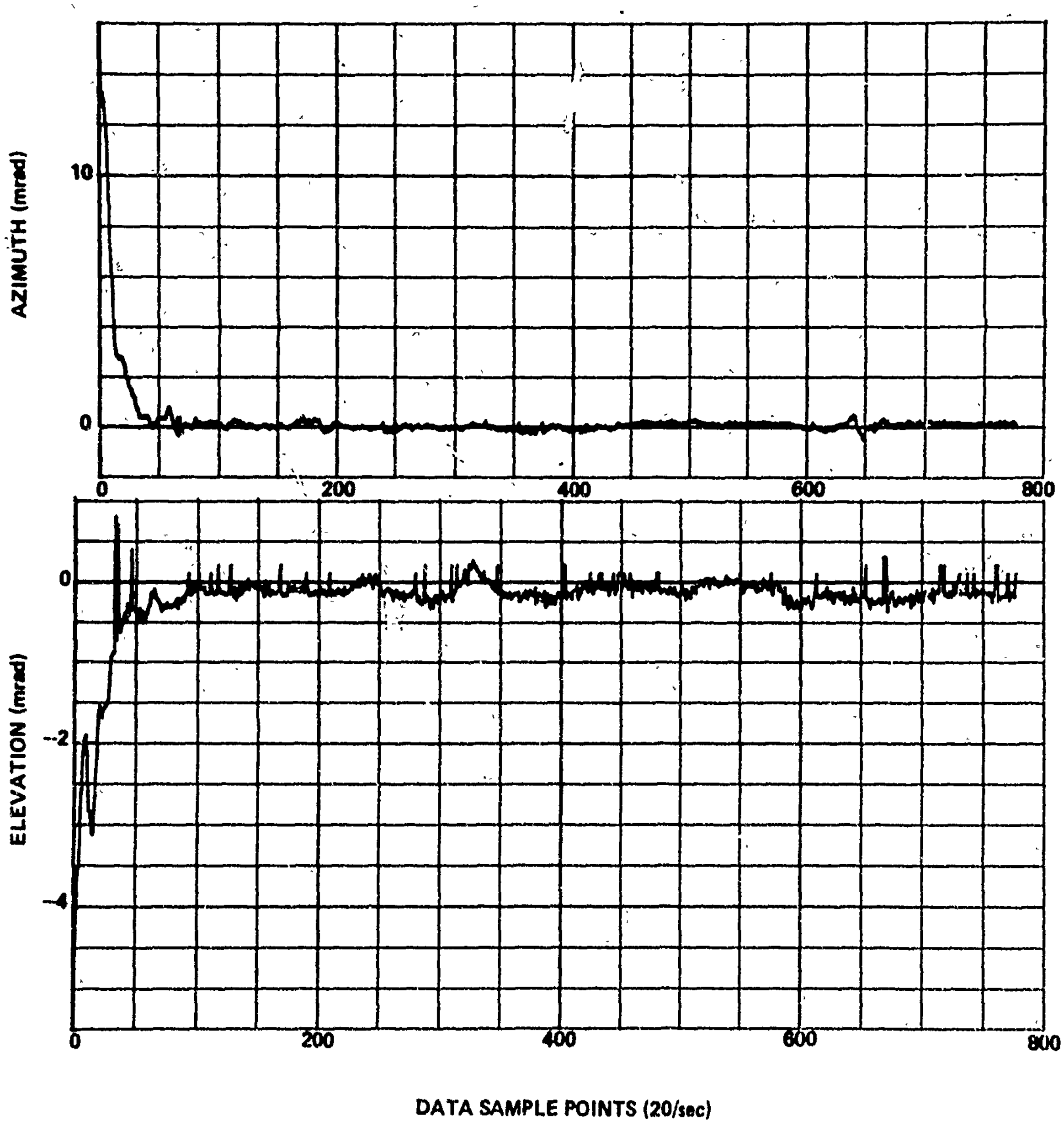


RUN 220
AZIMUTH (mrad)
1
0
−1
0
50
100
150
200
250
ELEVATION (mrad)
0
−5
0
50
100
150
200
250
DATA SAMPLE POINTS (20/sec)

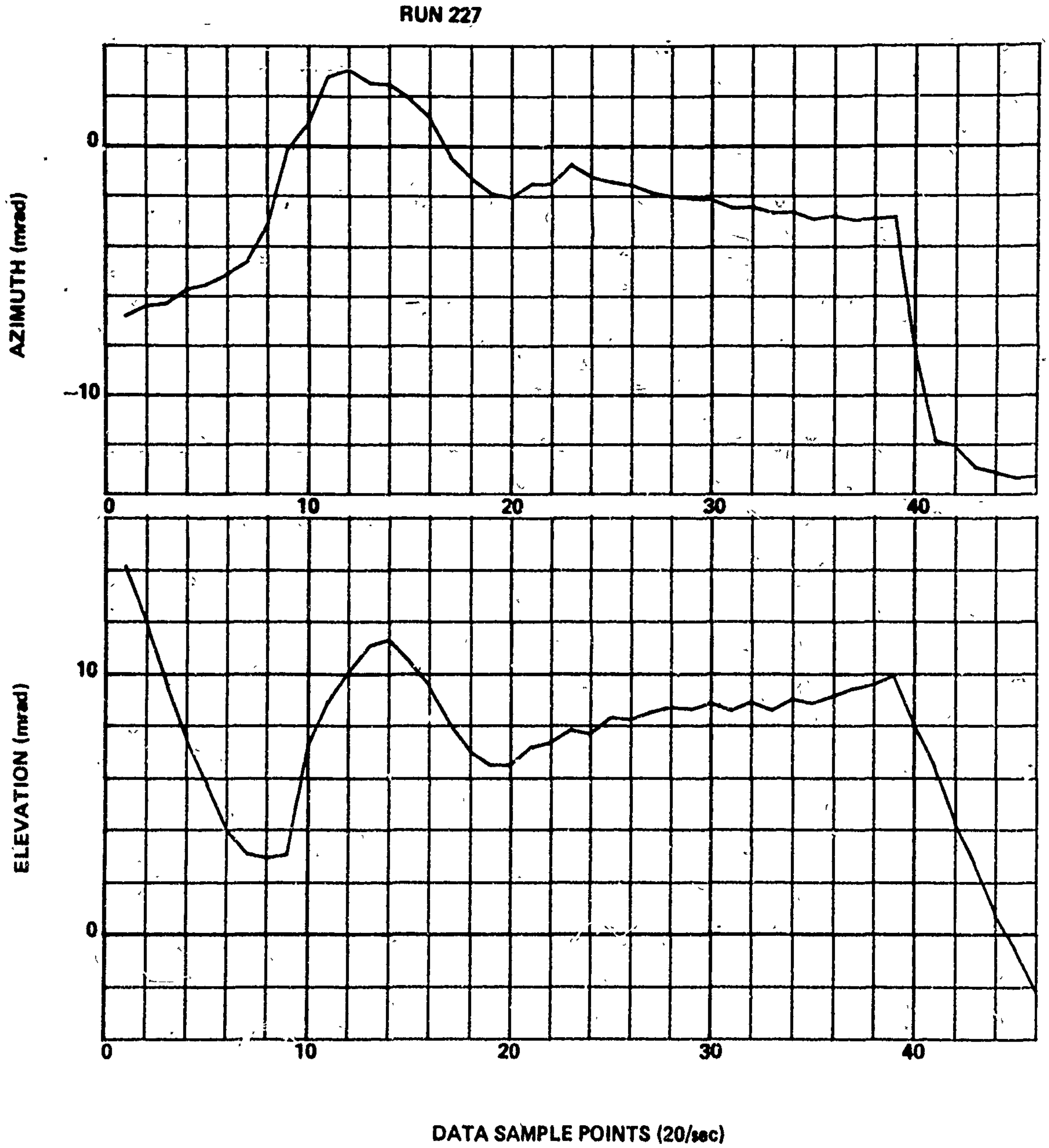

RUN 221
AZIMUTH (mrad)
0
0
200
400
600
800
ELEVATION (mrad)
0
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)


RUN 222
0.2000
0
-0.2000
AZIMUTH (mrad)
2
0
ELEVATION (mrad)
0
20
40
60
80
100
120
DATA SAMPLE POINTS (20/sec)

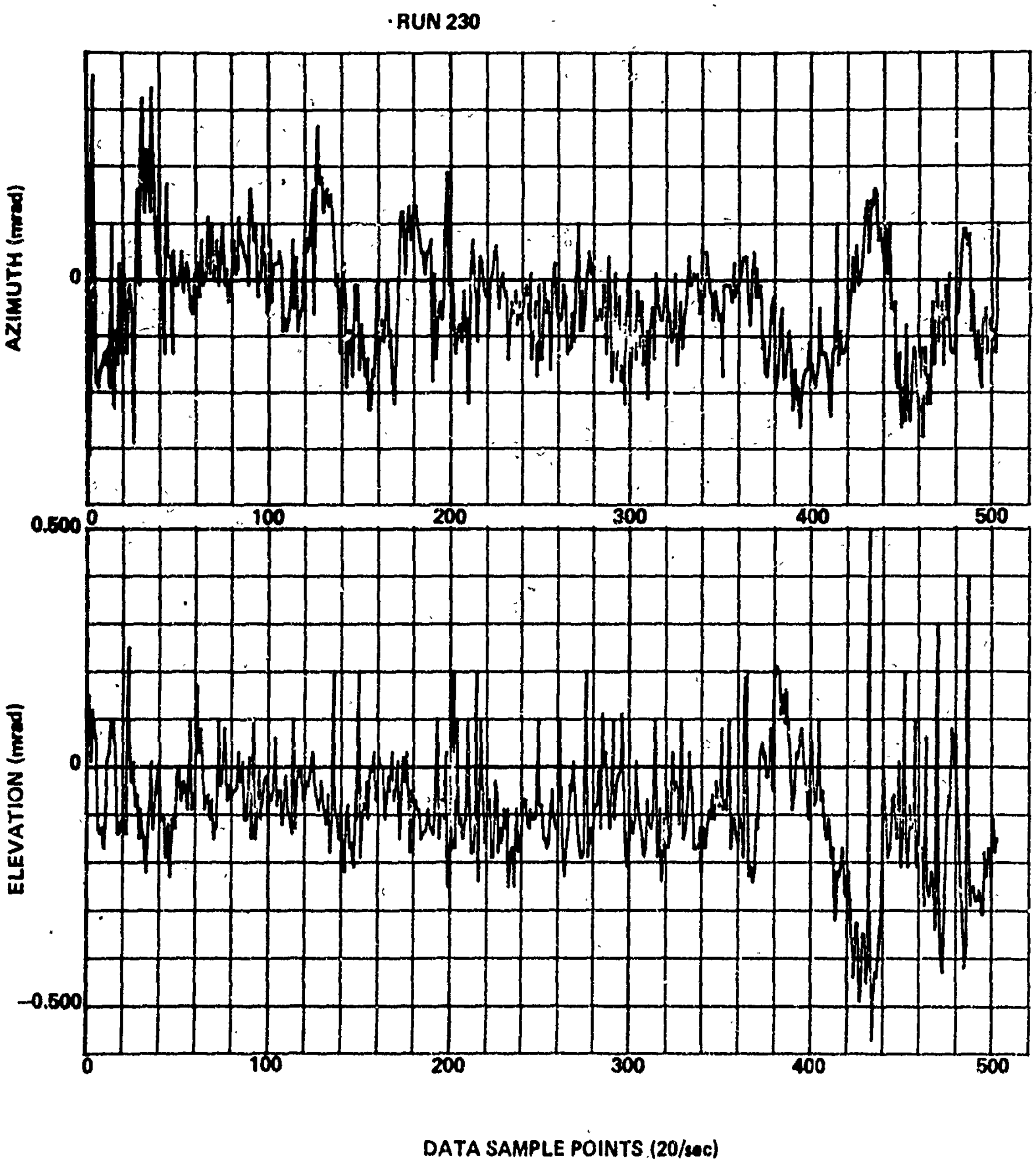
RUN 223

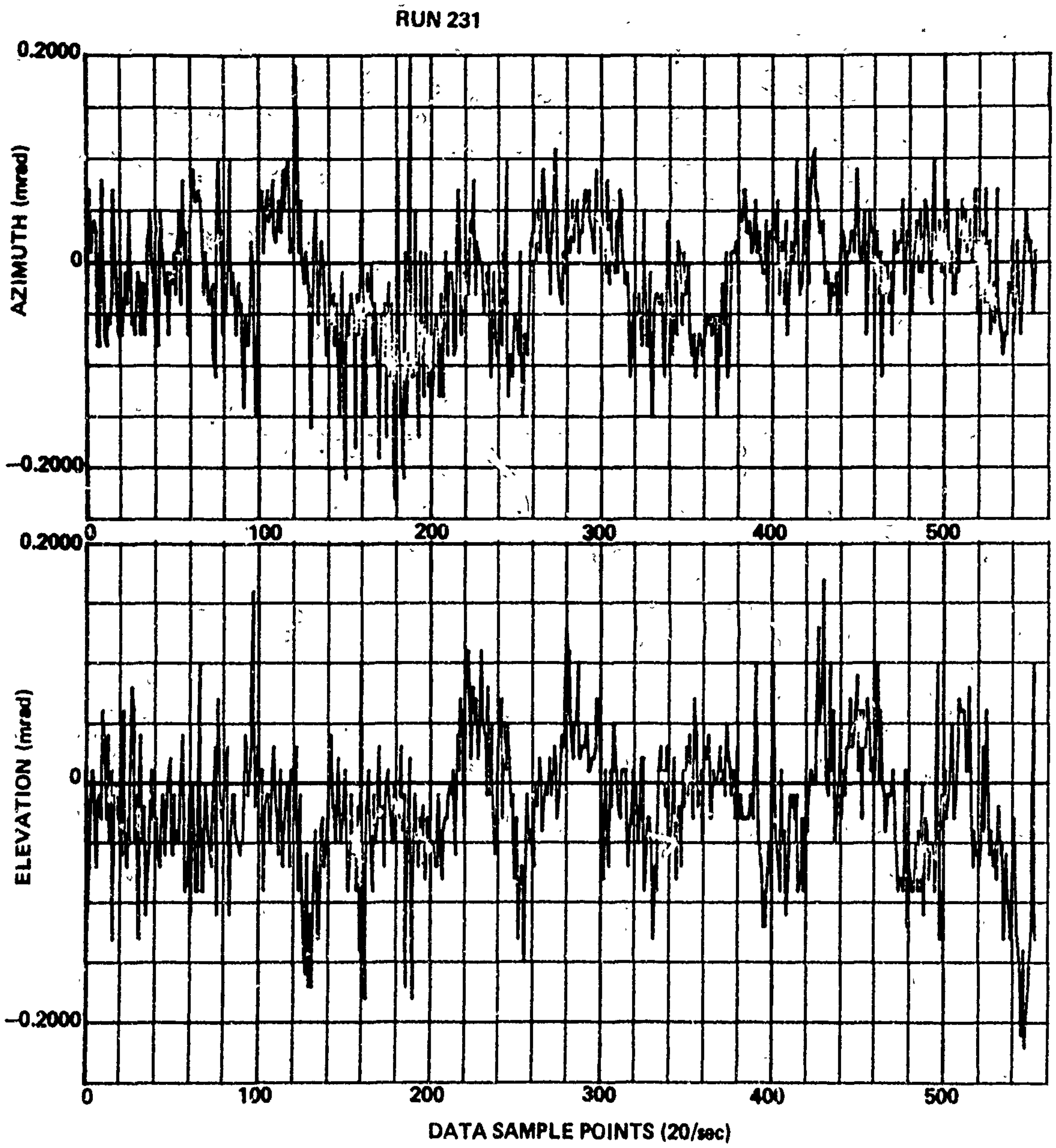


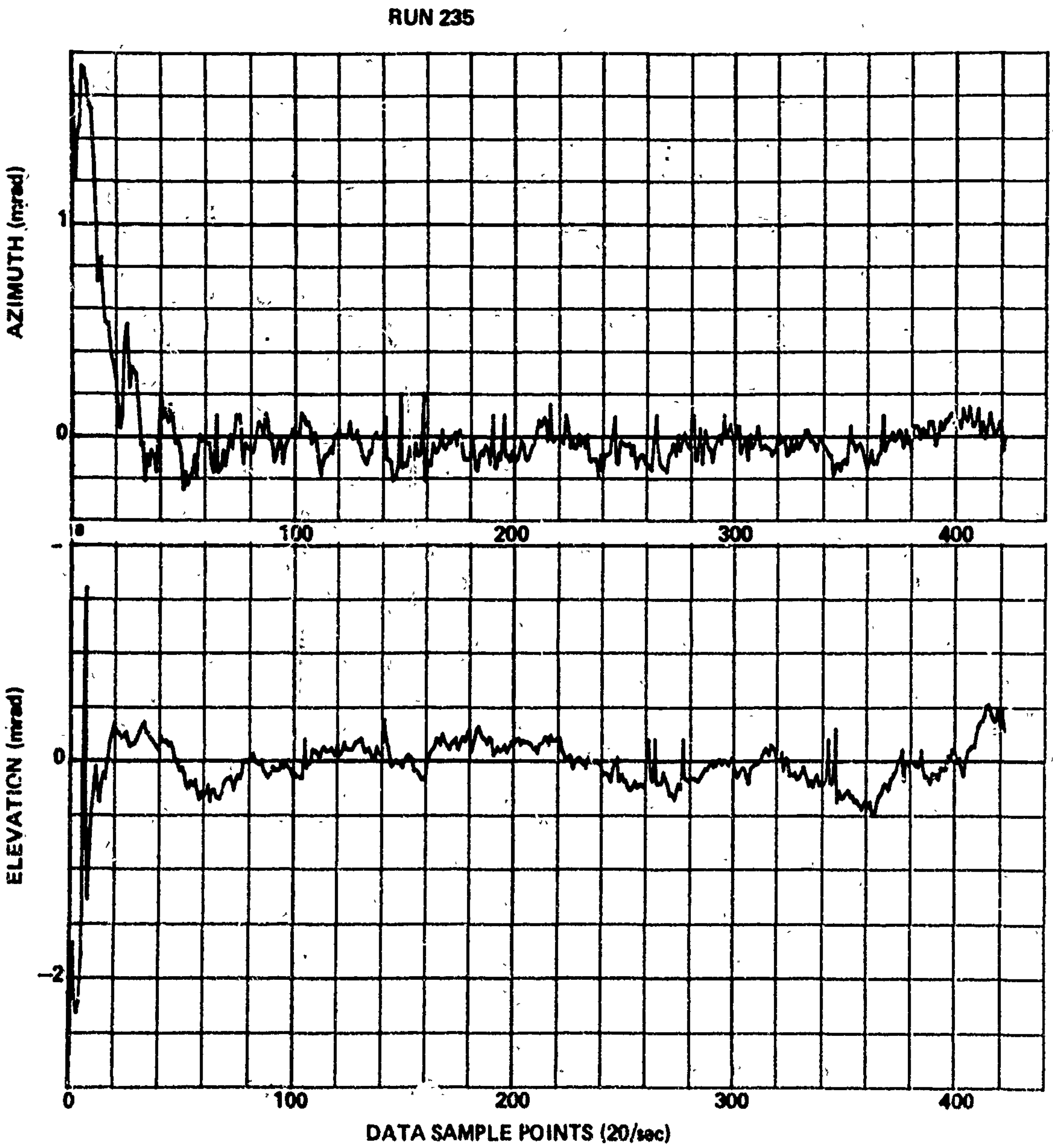
AZIMUTH (mrad)
10
0
0
200
400
600
800
ELEVATION (mrad)
0
-2
-4
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

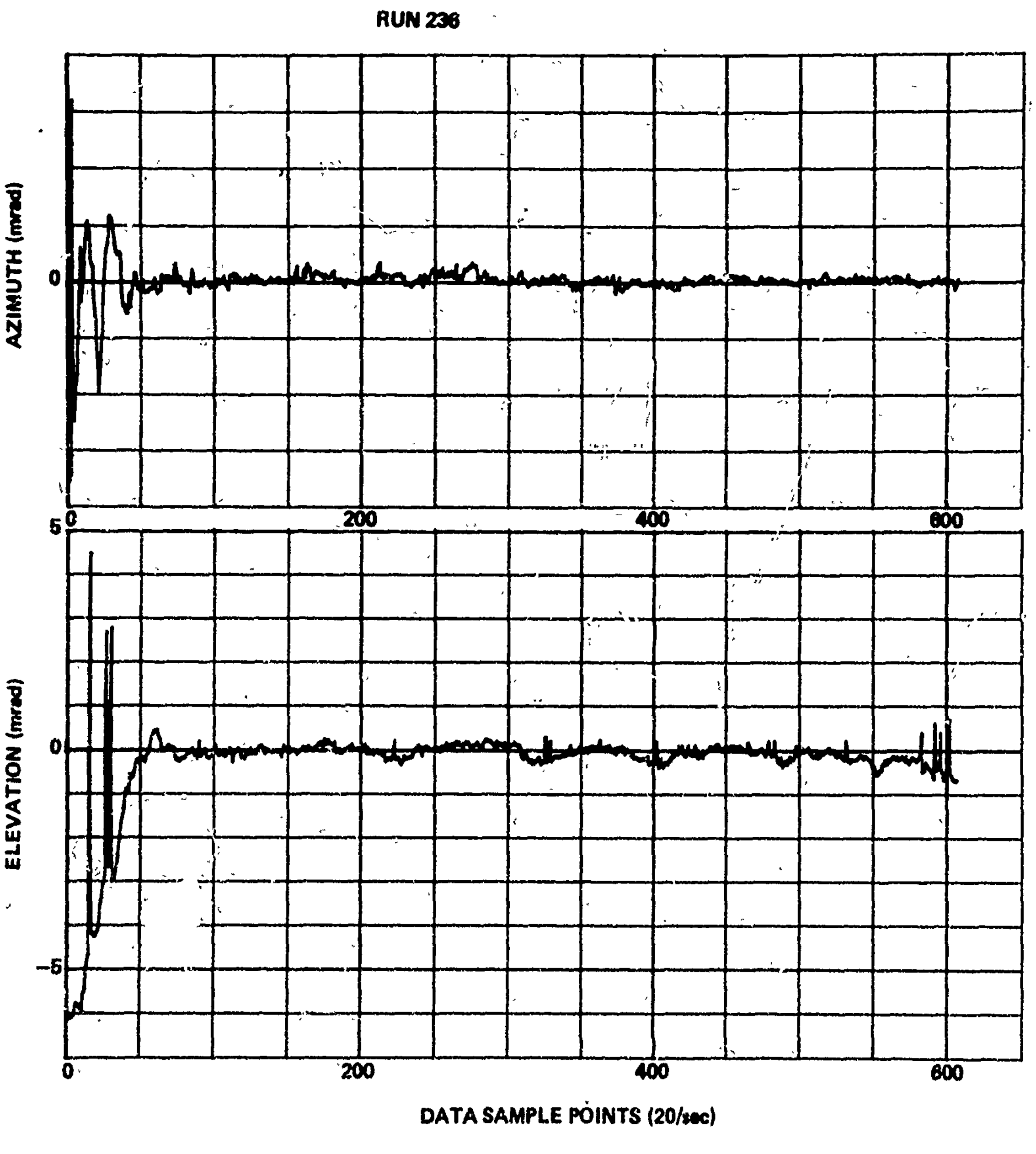


RUN 227
AZIMUTH (mrad)
0
−10
ELEVATION (mrad)
10
0
0
10
20
30
40
DATA SAMPLE POINTS (20/sec)

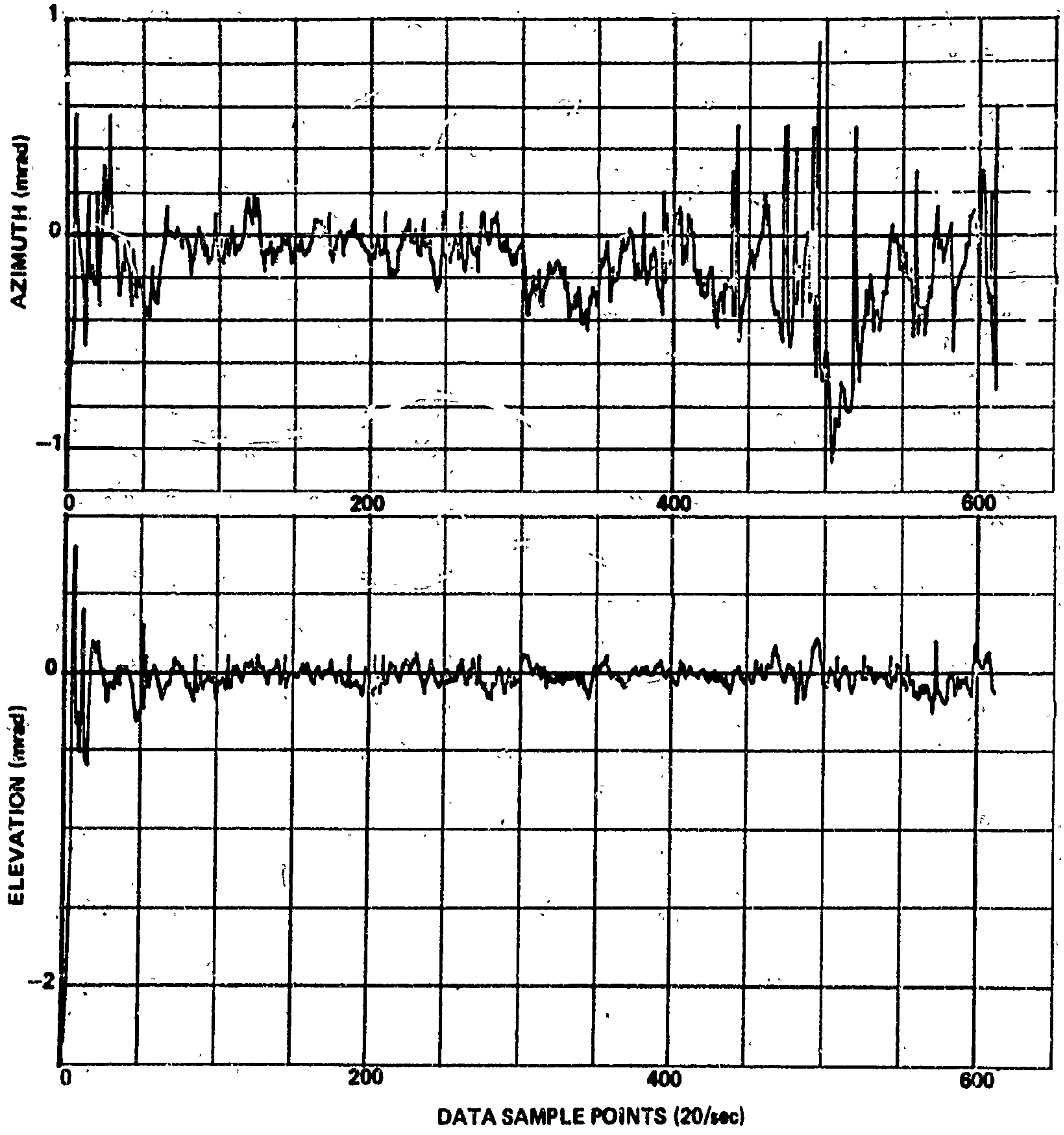

RUN 230
AZIMUTH (mrad)
0
0
100
200
300
400
500
0.500
ELEVATION (mrad)
0
-0.500
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)


RUN 231
0.2000
0
-0.2000
AZIMUTH (mrad)
0
100
200
300
400
500
0.2000
0
-0.2000
ELEVATION (mrad)
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)


RUN 235
AZIMUTH (mrad)
1
0
100
200
300
400
ELEVATION (mrad)
0
–2
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)

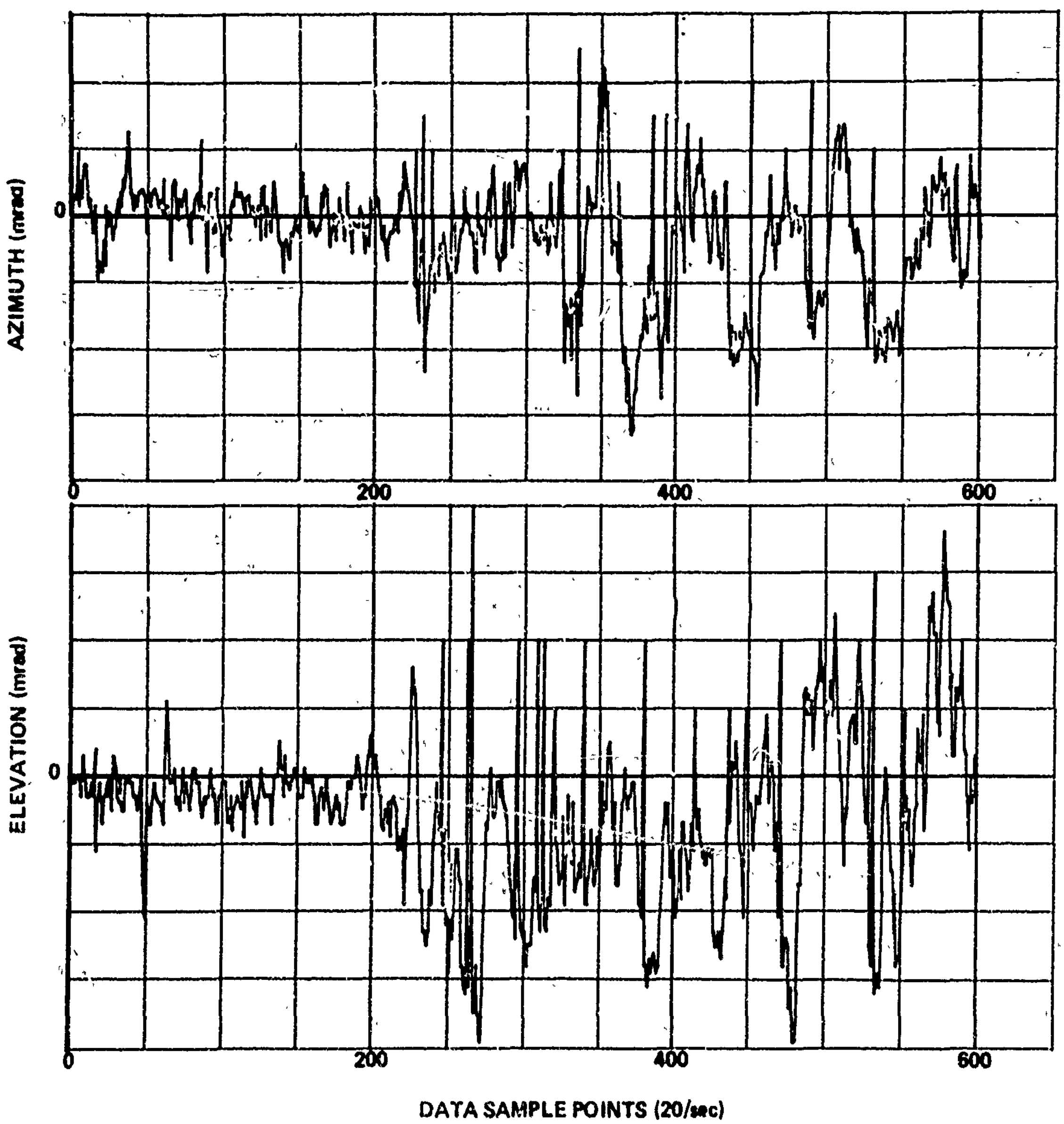

RUN 236
AZIMUTH (mrad)
0
0
200
400
600
5
ELEVATION (mrad)
0
−5
0
200
400
600
DATA SAMPLE POINTS (20/sec)

RUN 3

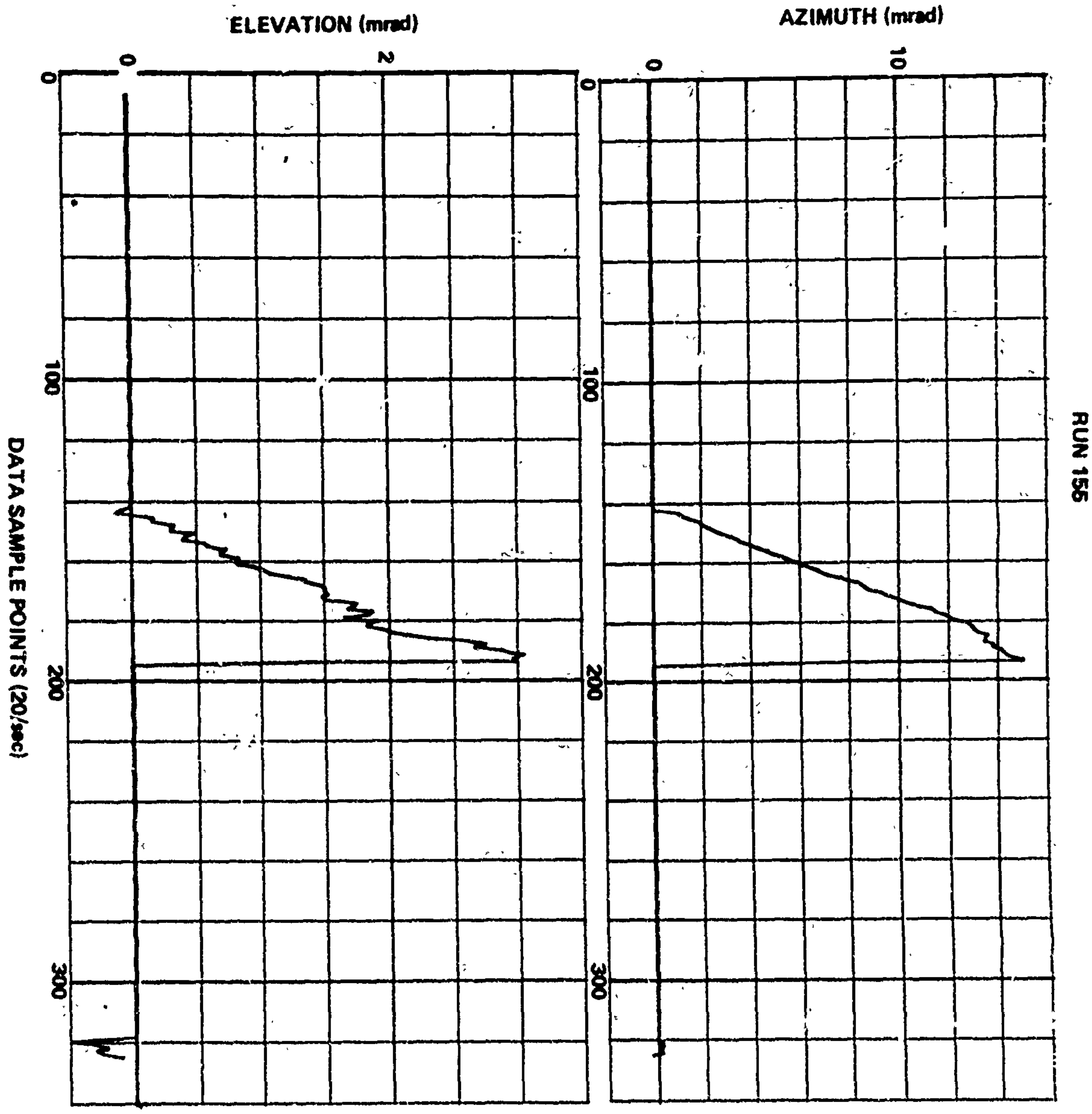


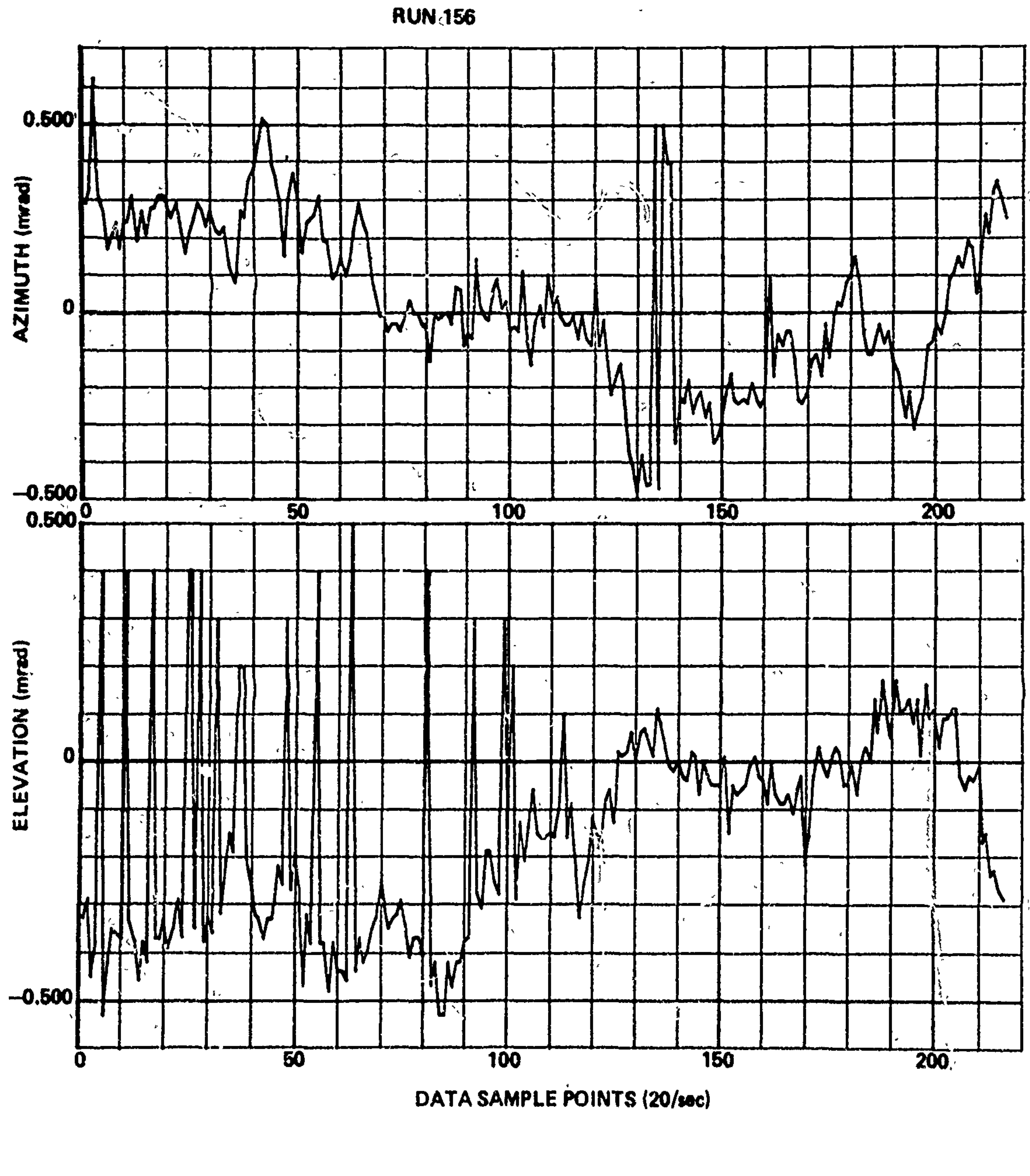
1
0
-1
AZIMUTH (mrad)
0
200
400
600
0
-2
ELEVATION (mrad)
0
200
400
600
DATA SAMPLE POINTS (20/sec)

RUN 4



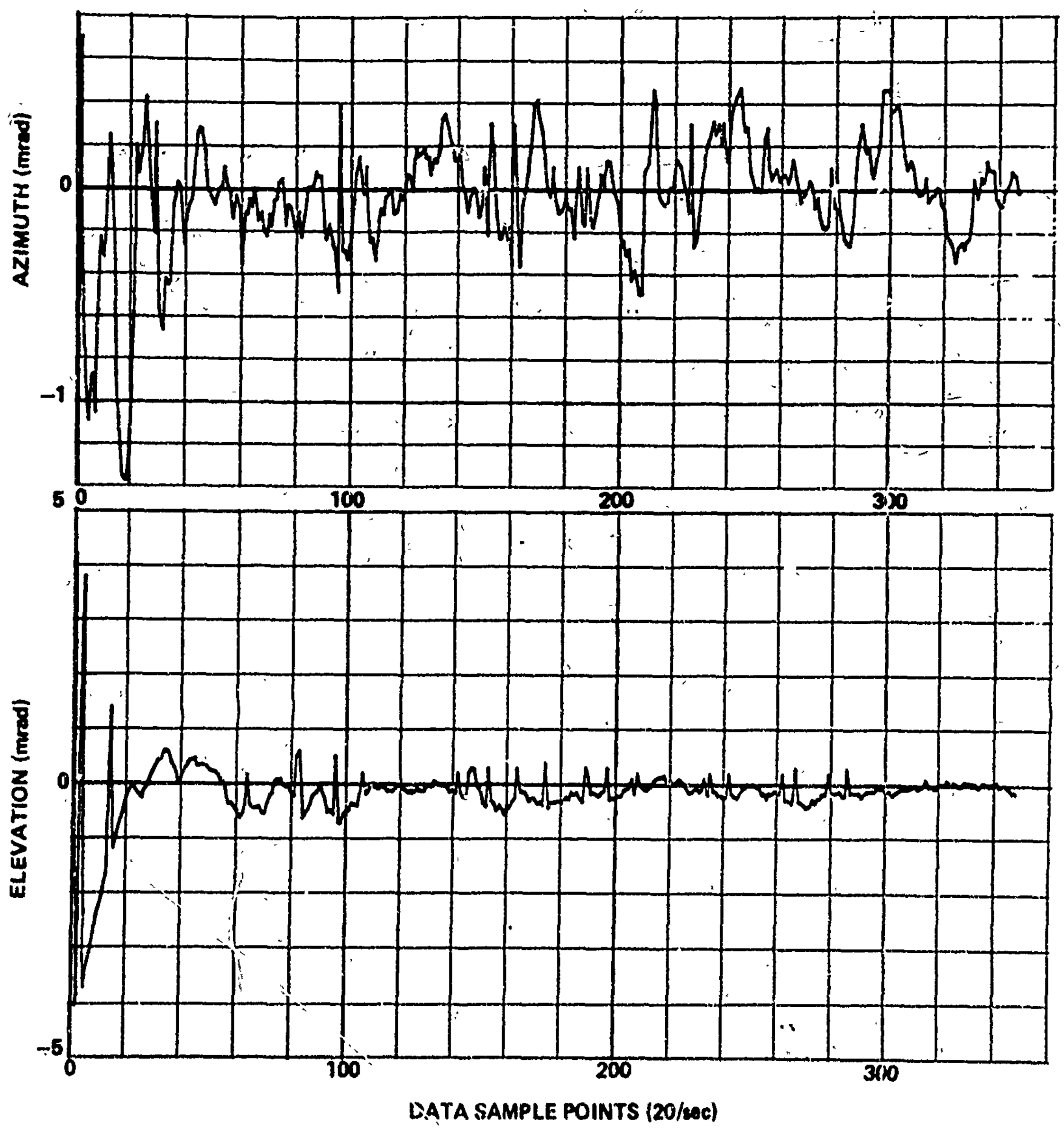
AZIMUTH (mrad)
0
0
200
400
600
ELEVATION (mrad)
0
0
200
400
600
DATA SAMPLE POINTS (20/sec)


ELEVATION (mrad)
AZIMUTH (mrad)
RUN 155
DATA SAMPLE POINTS (20/sec)
0
2
10
100
200
300

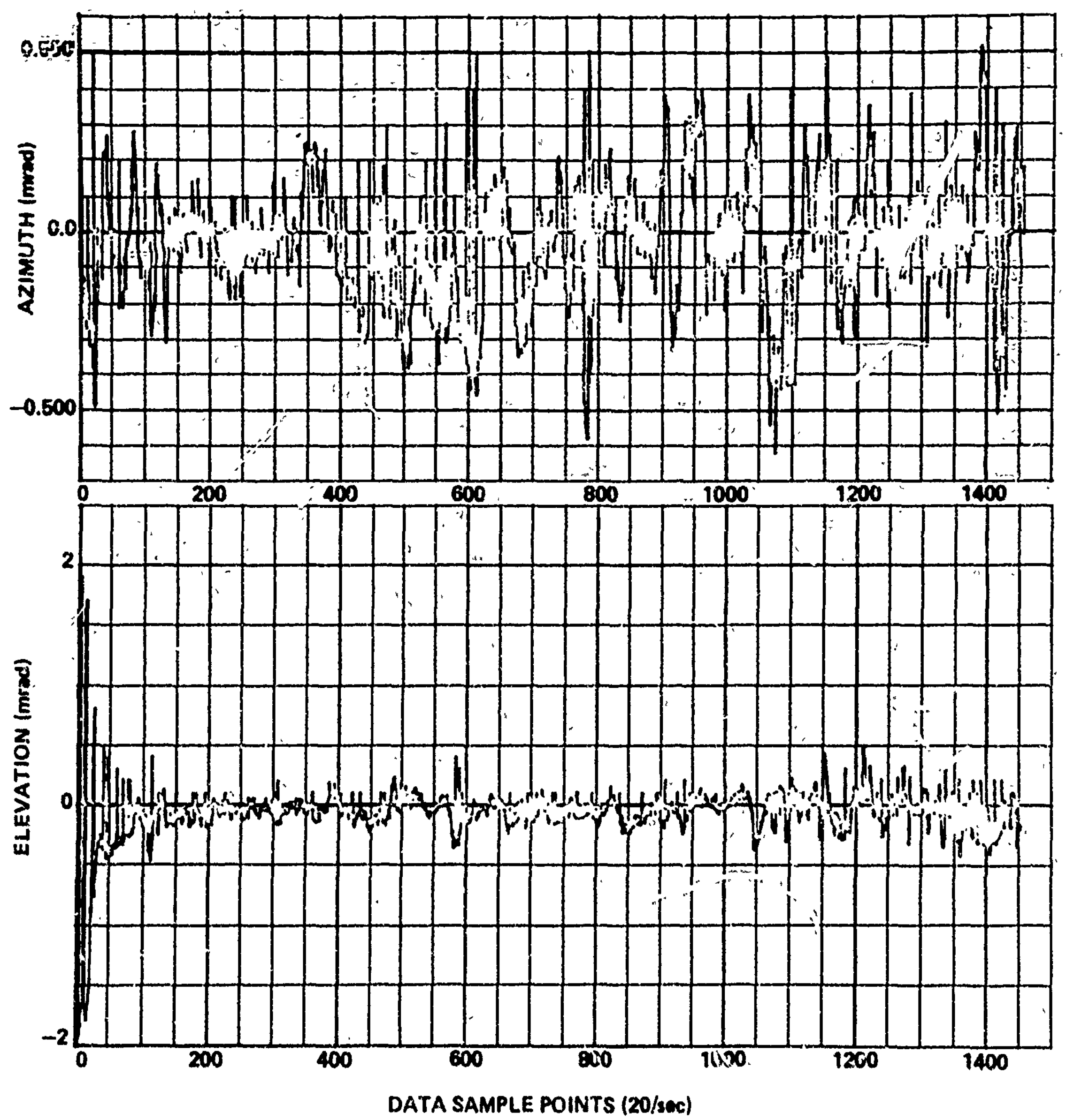


RUN 156
AZIMUTH (mrad)
0.500
0
–0.500
ELEVATION (mrad)
0.500
0
–0.500
0
50
100
150
200
DATA SAMPLE POINTS (20/sec)

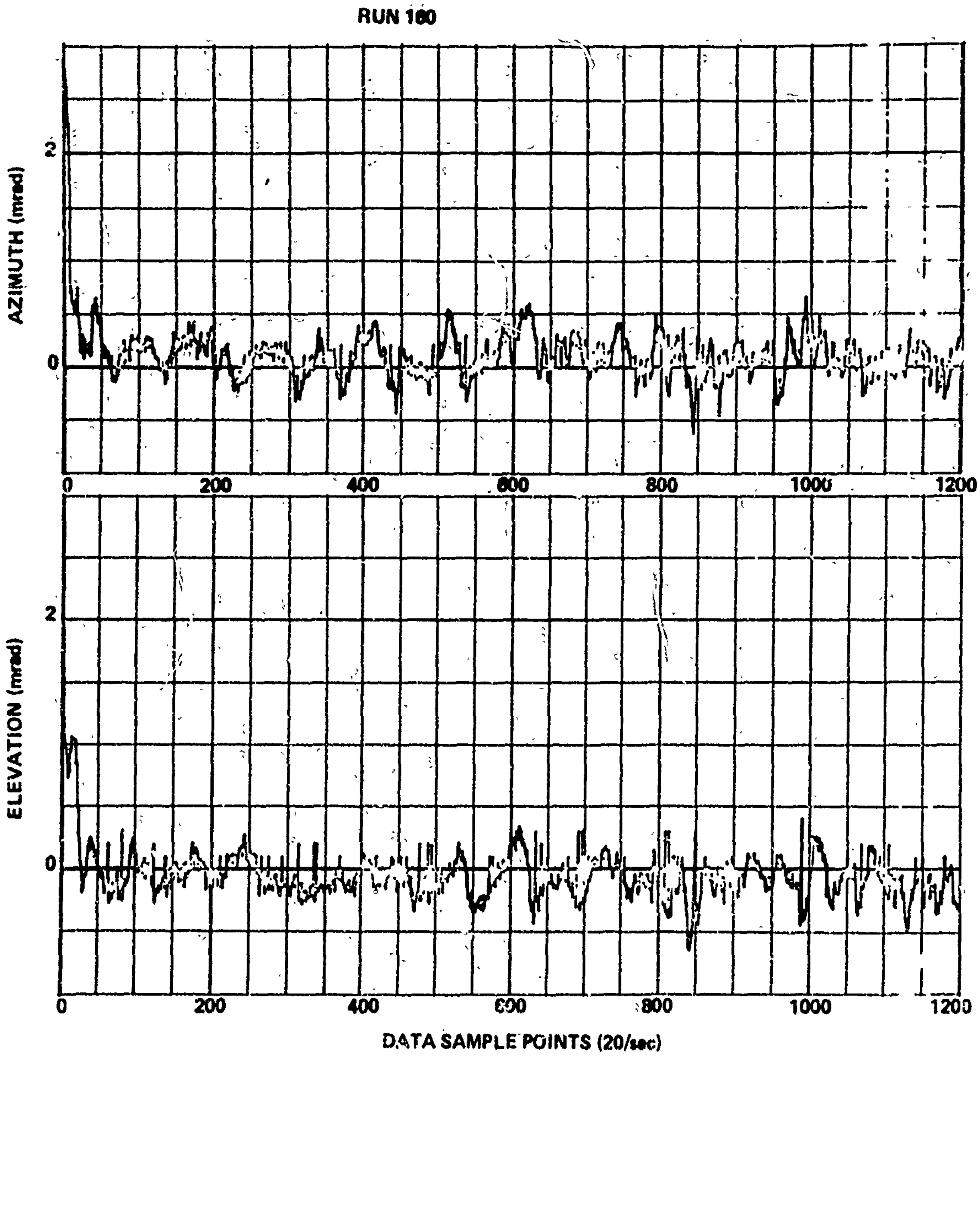
RUN 158


AZIMUTH (mrad)
0
-1
0
100
200
300
5
ELEVATION (mrad)
0
-5
0
100
200
300
DATA SAMPLE POINTS (20/sec)

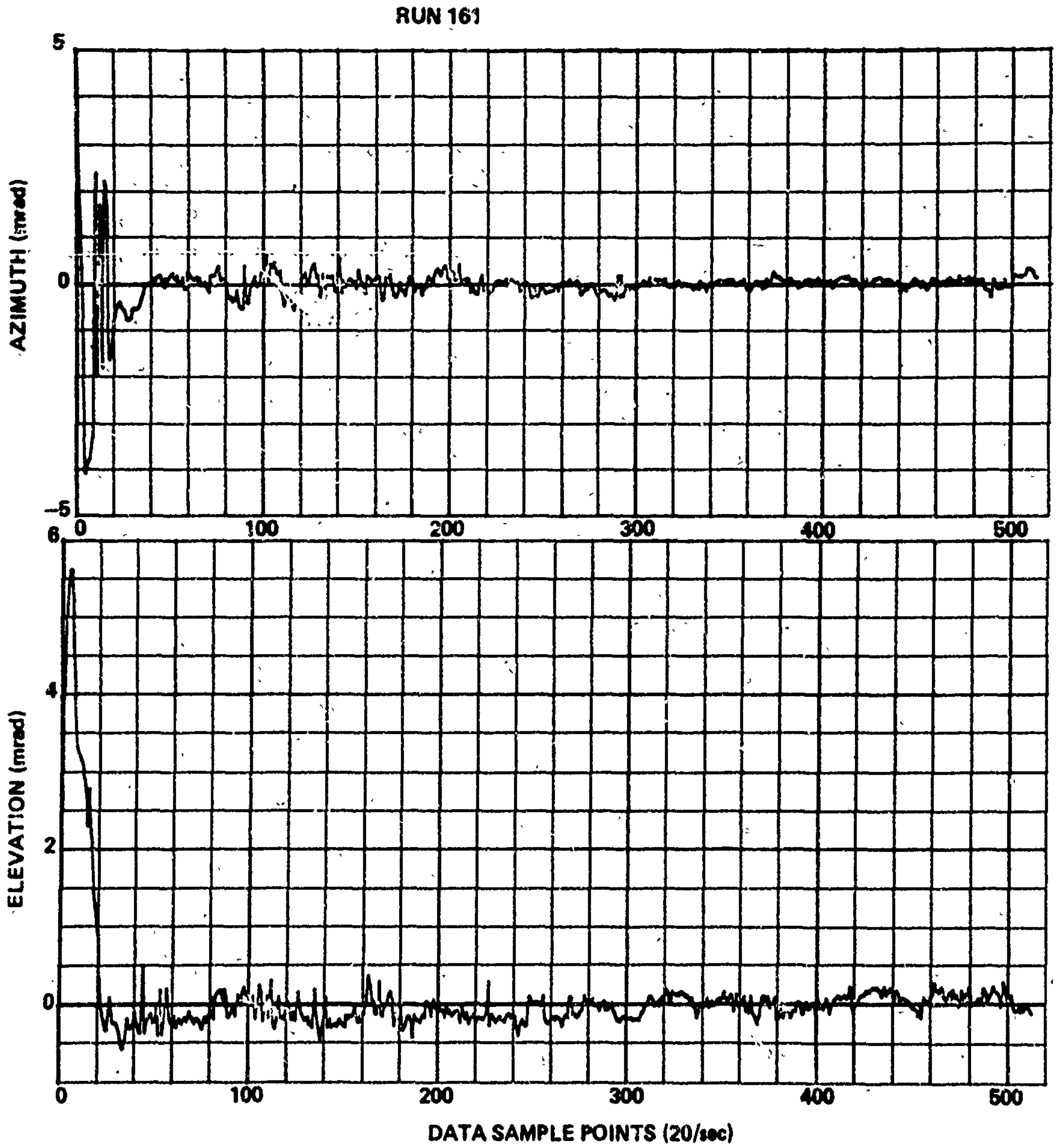
RUN 159

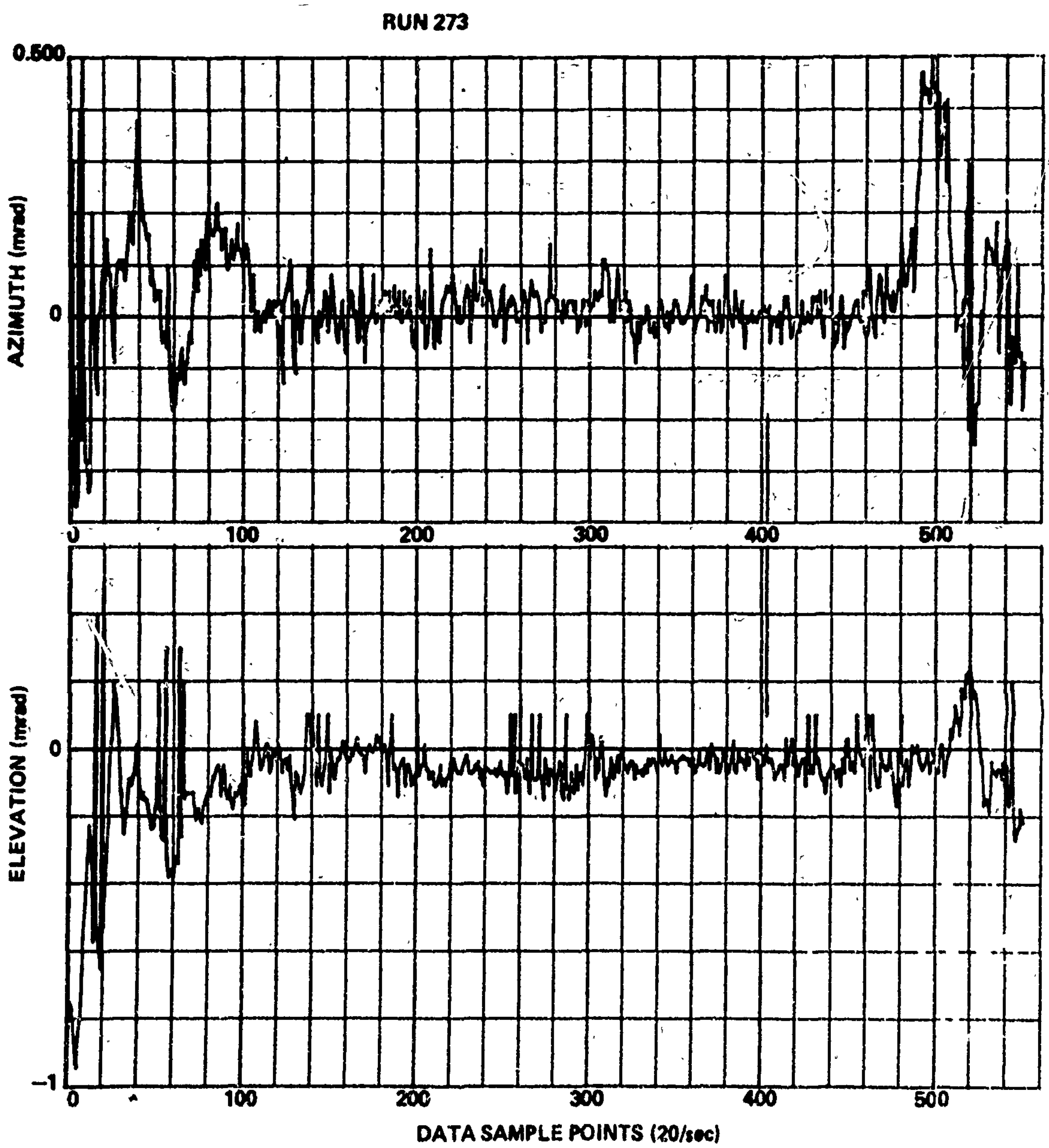


0.500
0.0
−0.500
AZIMUTH (mrad)
0
200
400
600
800
1000
1200
1400
2
0
−2
ELEVATION (mrad)
0
200
400
600
800
1000
1200
1400
DATA SAMPLE POINTS (20/sec)



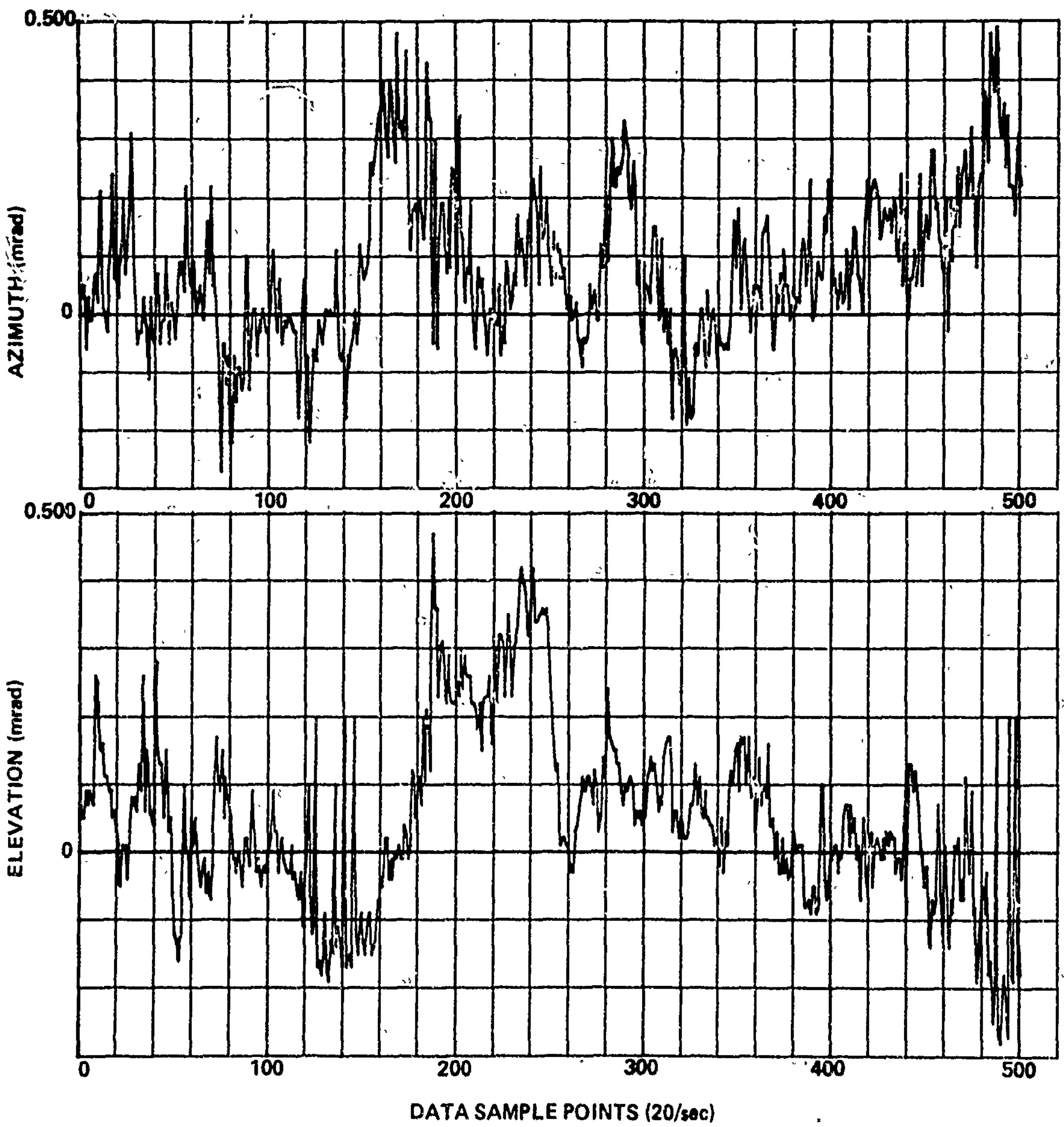
RUN 160
AZIMUTH (mrad)
2
0
0
200
400
600
800
1000
1200
ELEVATION (mrad)
2
0
0
200
400
600
800
1000
1200
DATA SAMPLE POINTS (20/sec)


RUN 161
5
0
-5
AZIMUTH (mrad)
0
100
200
300
400
500
6
4
2
0
ELEVATION (mrad)
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)



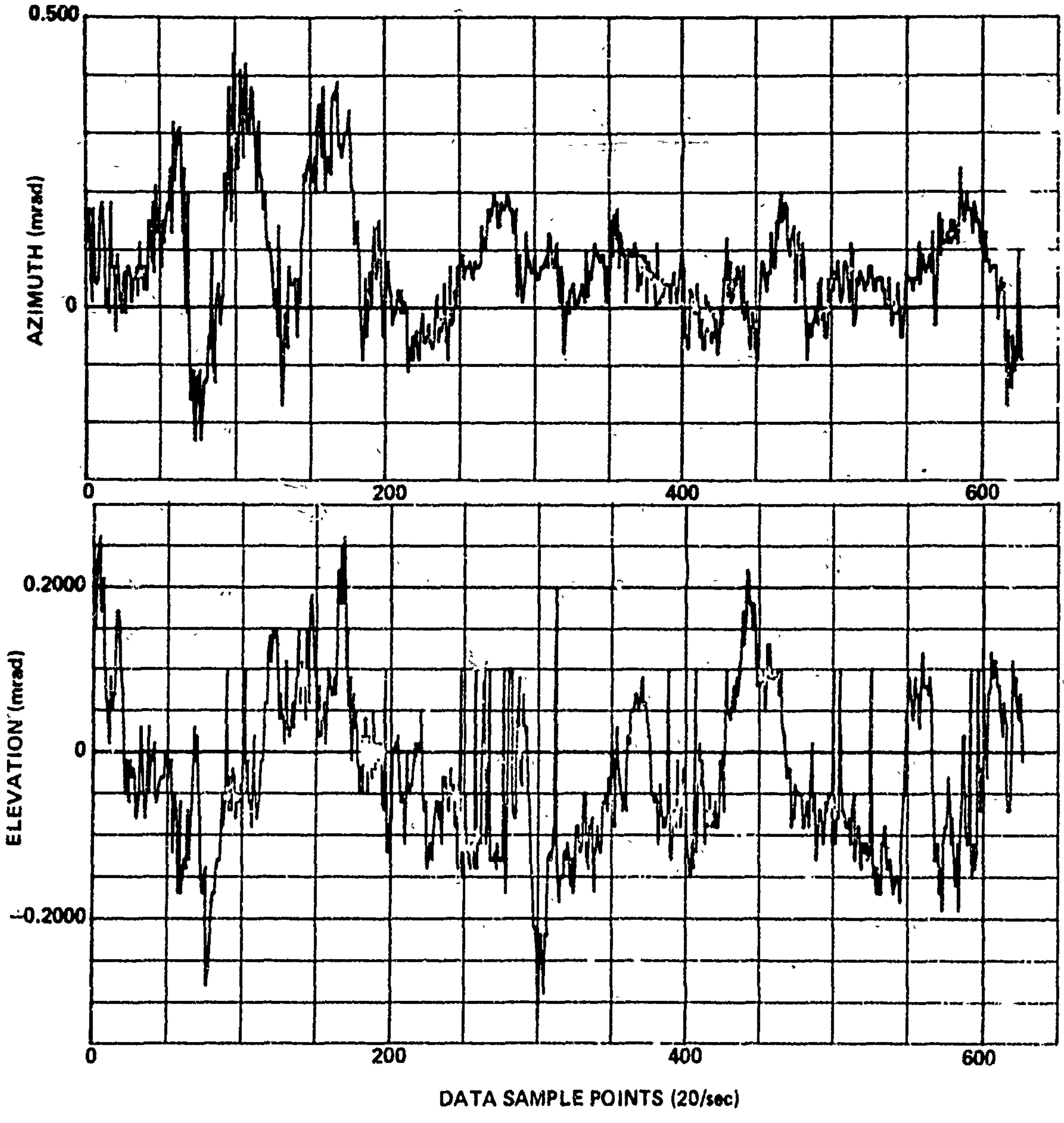
RUN 273
0.500
AZIMUTH (mrad)
0
0
100
200
300
400
500
ELEVATION (mrad)
0
−1
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

RUN 274

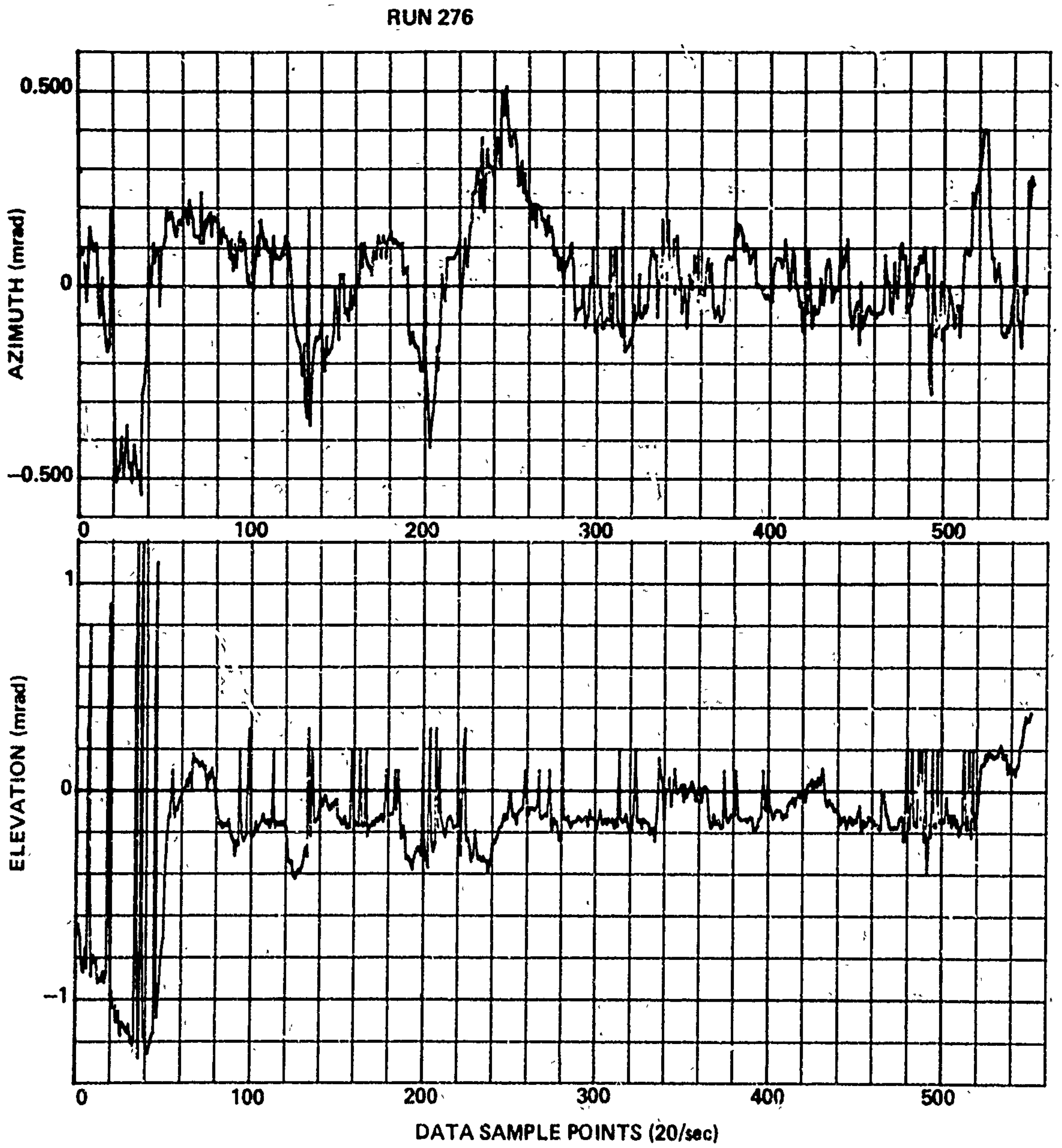


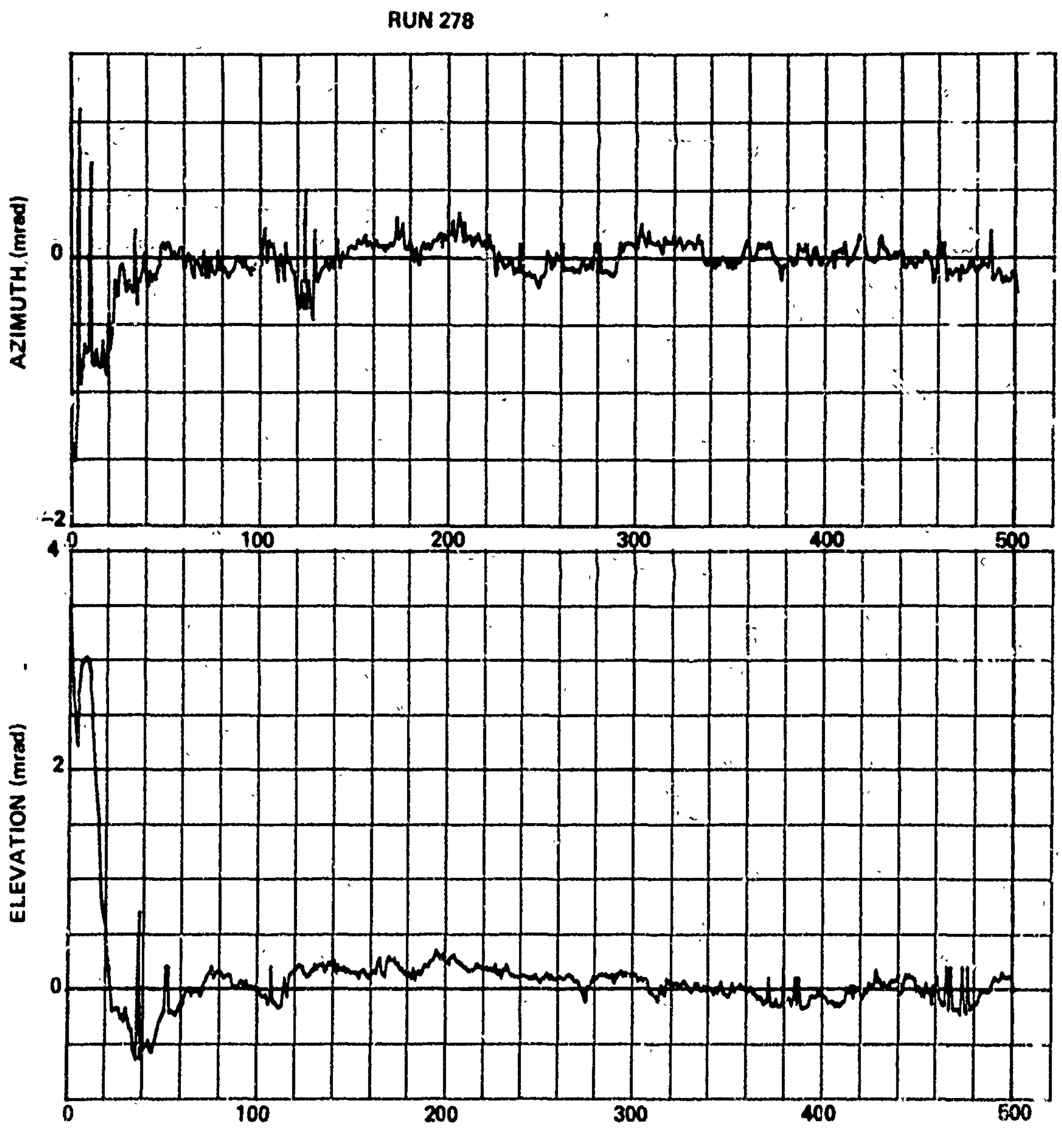
0.500
0
AZIMUTH (mrad)
0
100
200
300
400
500
0.500
0
ELEVATION (mrad)
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

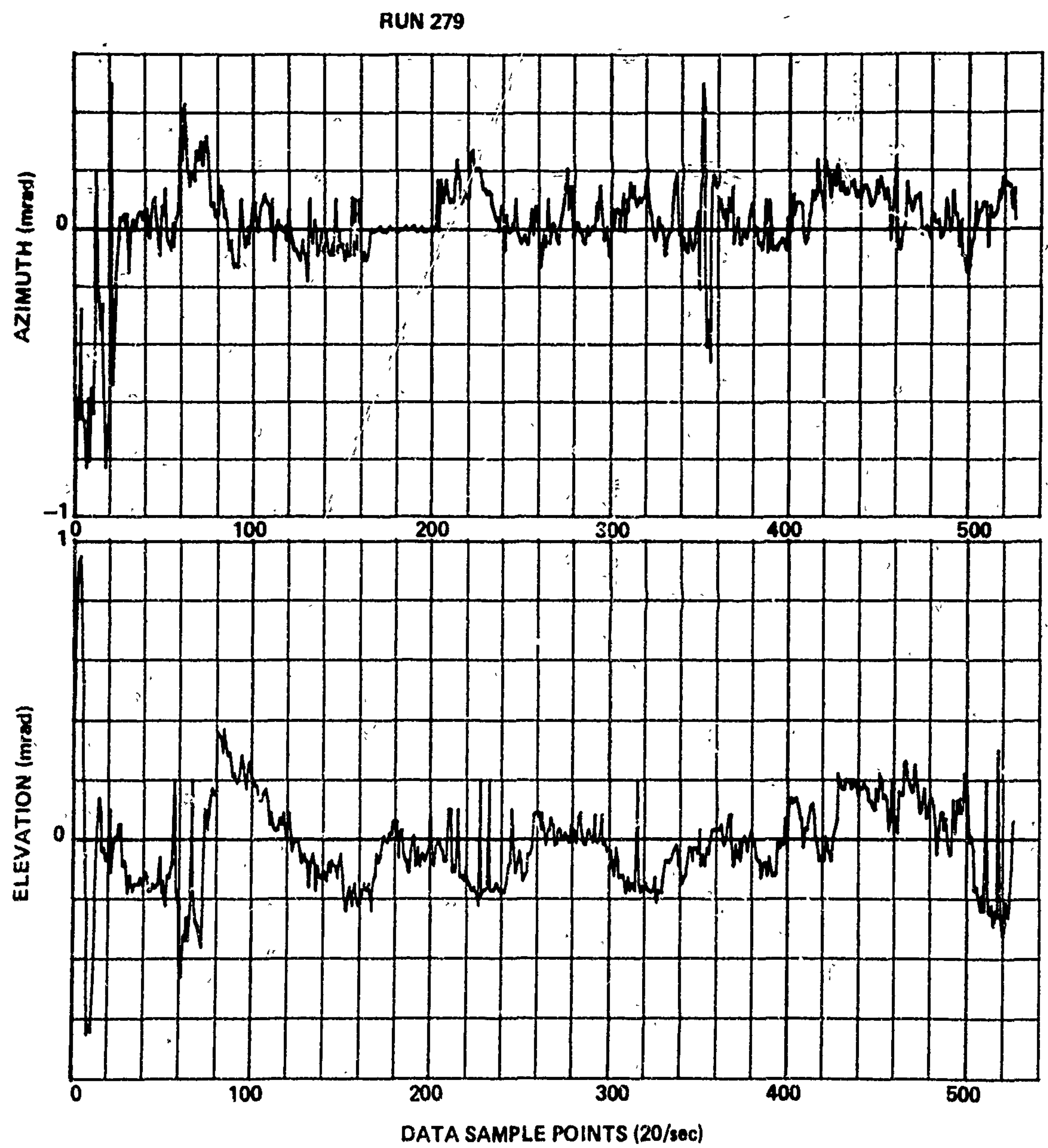
RUN 275



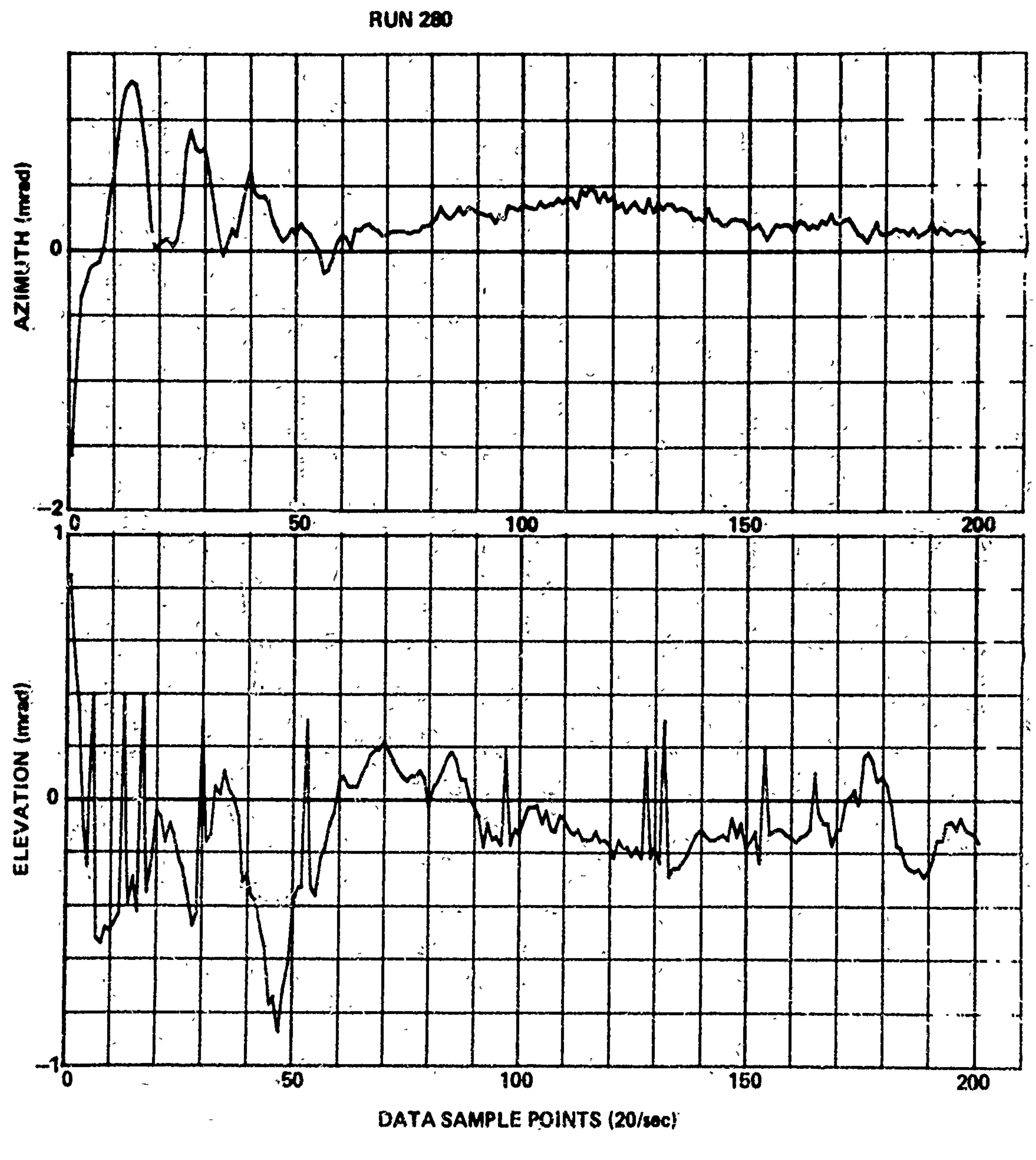
0.500
AZIMUTH (mrad)
0
0
200
400
600
0.2000
ELEVATION (mrad)
0
-0.2000
0
200
400
600
DATA SAMPLE POINTS (20/sec)

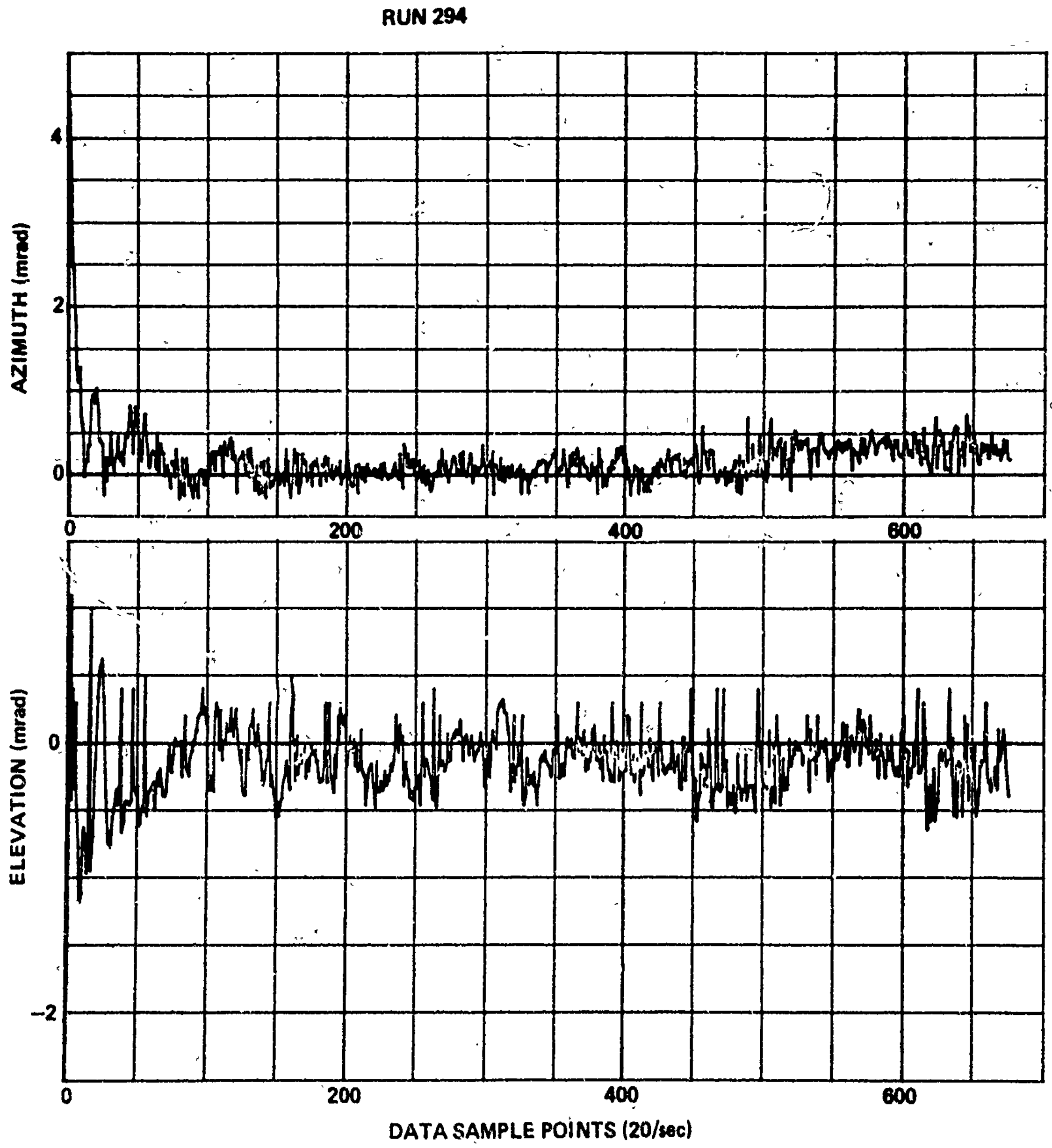

RUN 276
AZIMUTH (mrad)
0.500
0
–0.500
0
100
200
300
400
500
ELEVATION (mrad)
1
0
–1
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

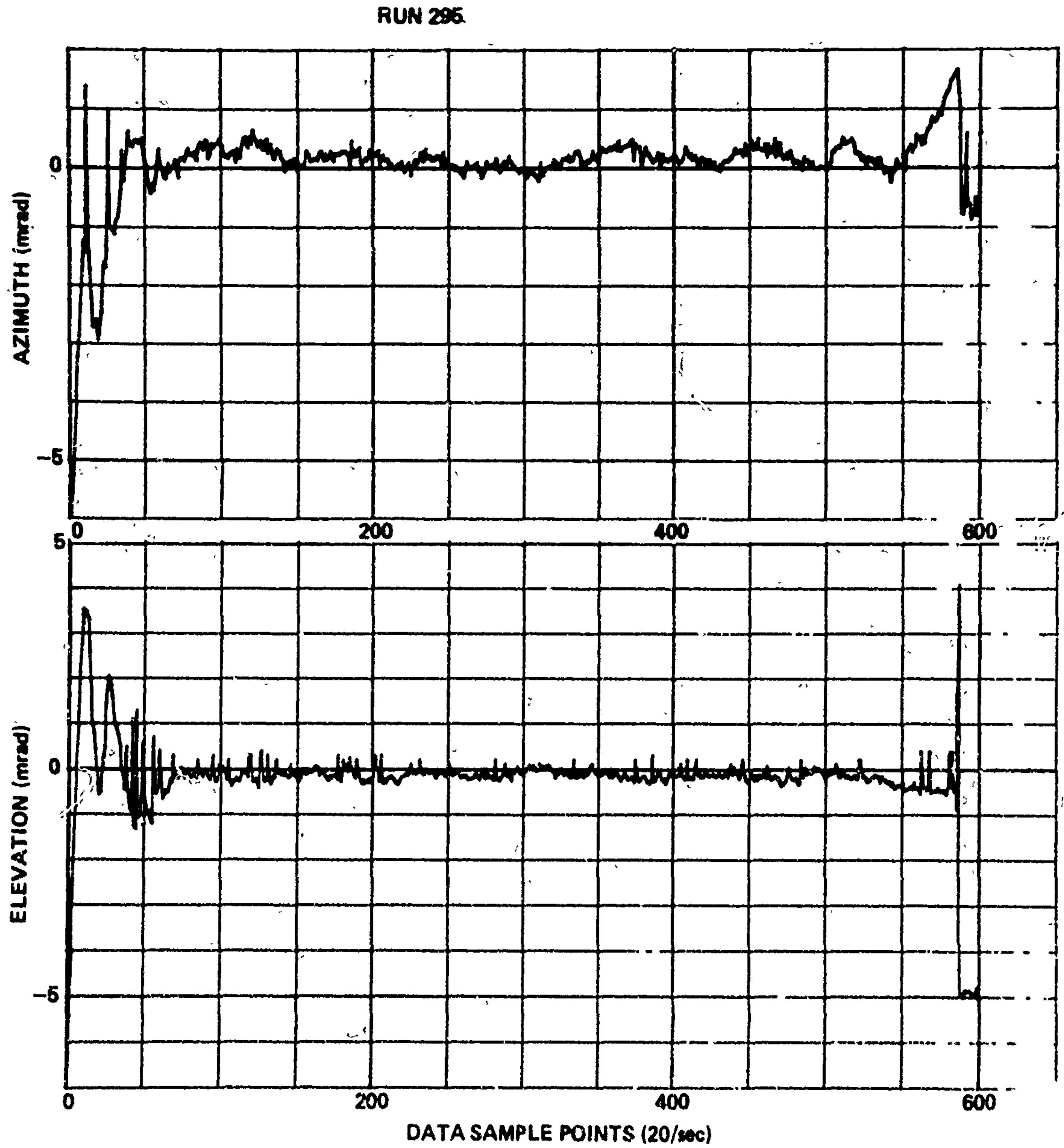

RUN 278
AZIMUTH (mrad)
0
-2
ELEVATION (mrad)
4
2
0
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

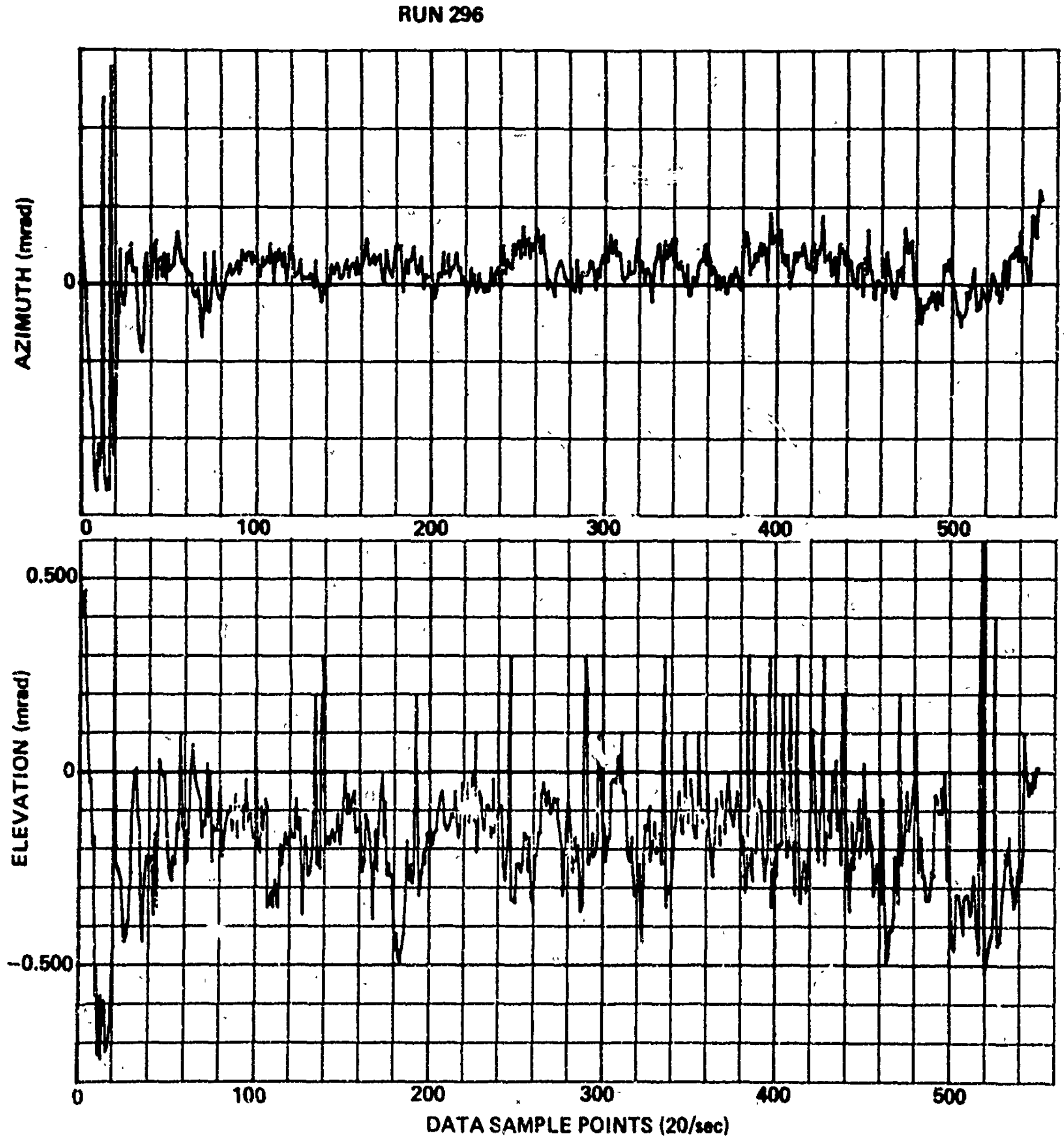


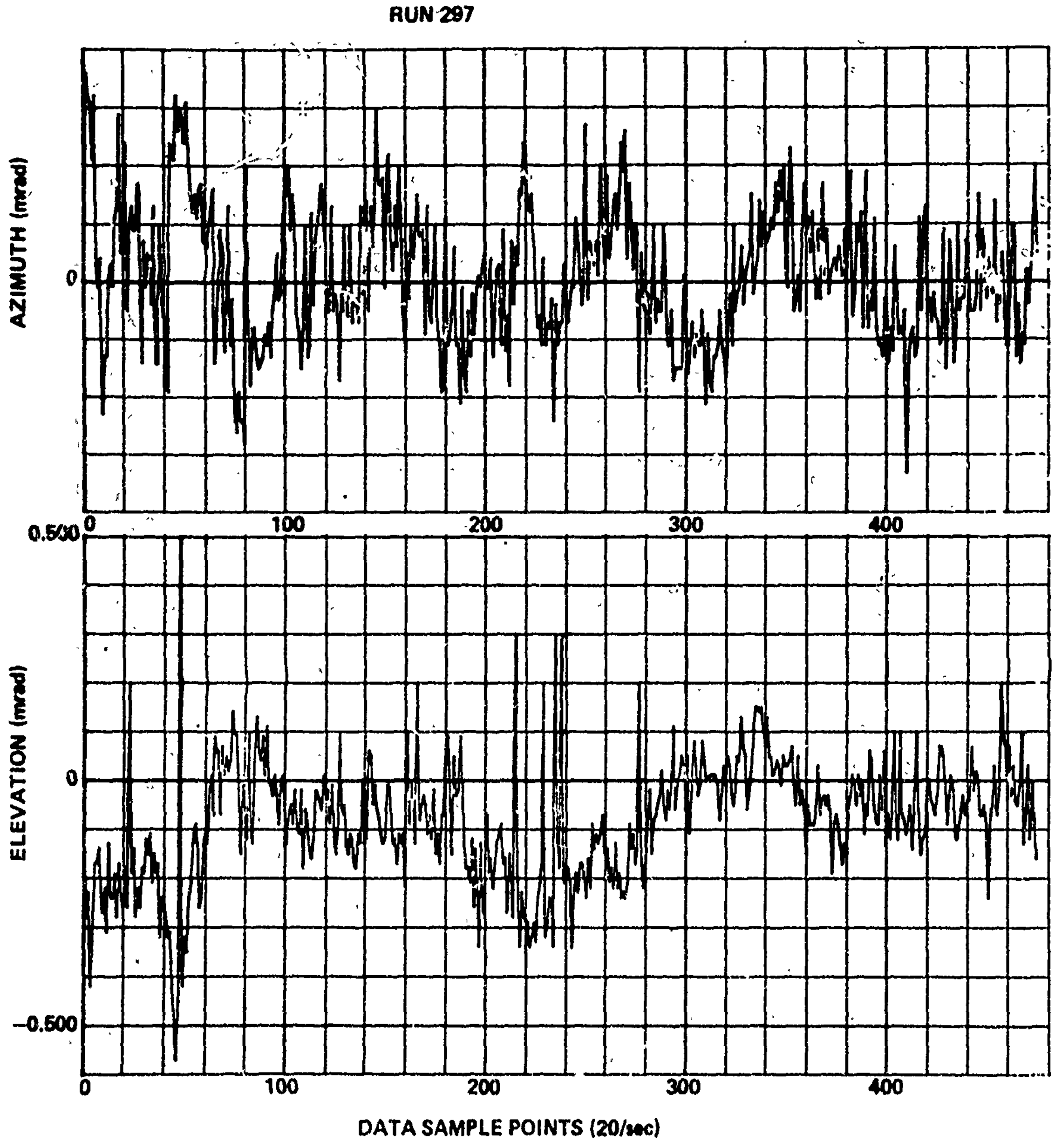
RUN 279
AZIMUTH (mrad)
0
-1
1
ELEVATION (mrad)
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)


RUN 280
AZIMUTH (mrad)
ELEVATION (mrad)
0
-2
1
0
-1
0
50
100
150
200
DATA SAMPLE POINTS (20/sec)

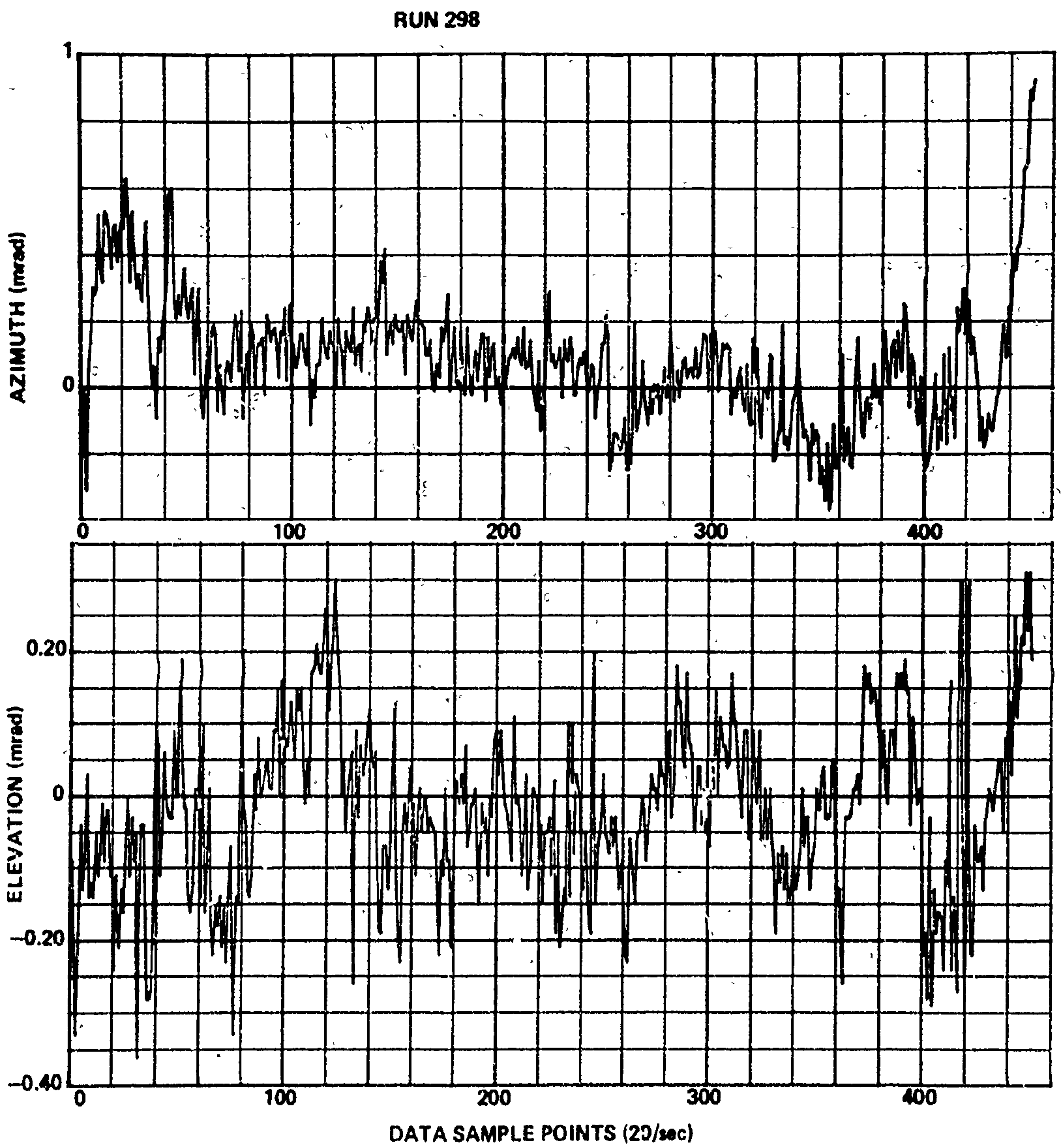

RUN 294
AZIMUTH (mrad)
4
2
0
0
200
400
600
ELEVATION (mrad)
0
−2
0
200
400
600
DATA SAMPLE POINTS (20/sec)


RUN 295
AZIMUTH (mrad)
0
-5
0
200
400
600
5
ELEVATION (mrad)
0
-5
0
200
400
600
DATA SAMPLE POINTS (20/sec)

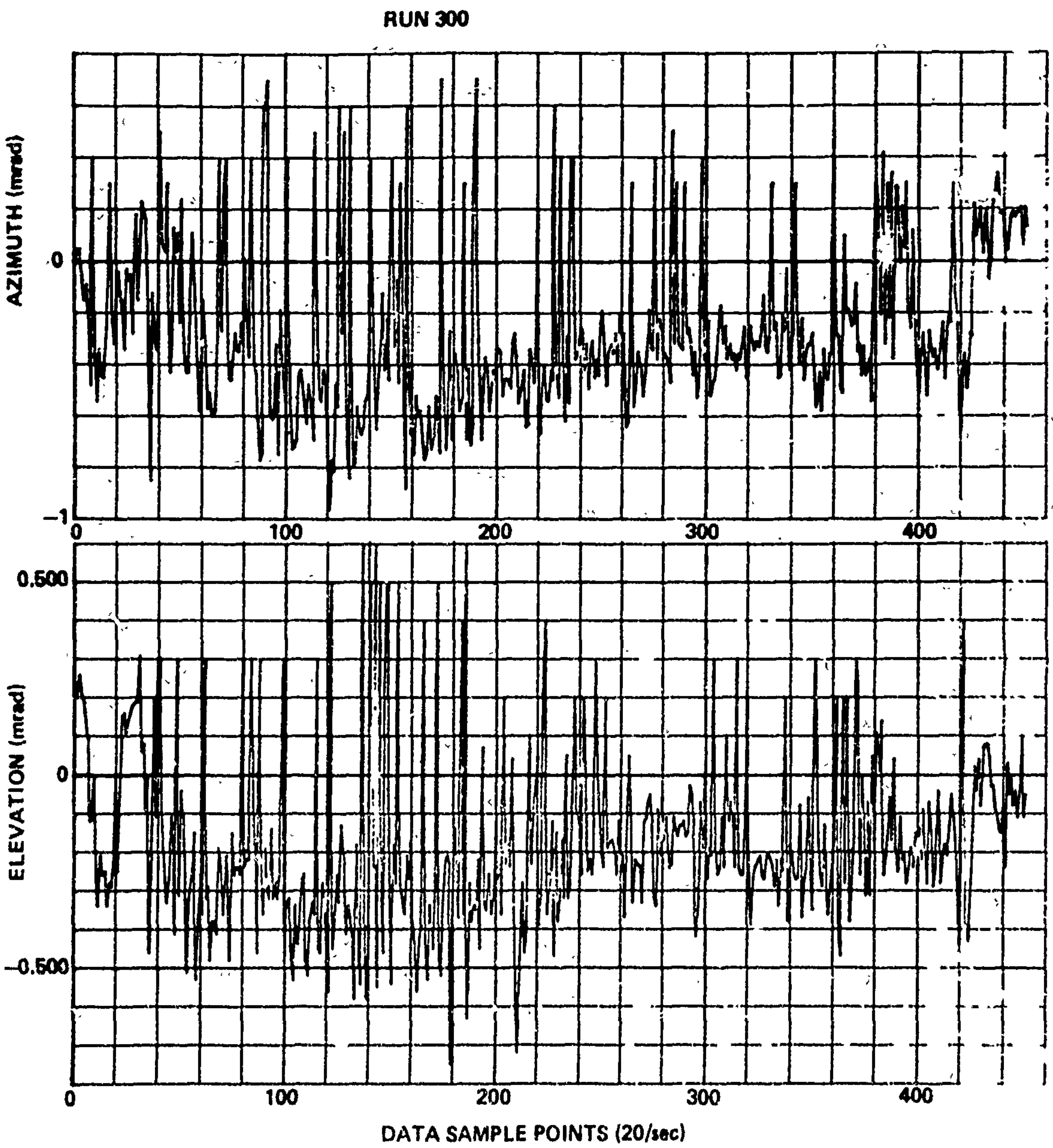

RUN 296
AZIMUTH (mrad)
0
0
100
200
300
400
500
ELEVATION (mrad)
0.500
0
−0.500
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

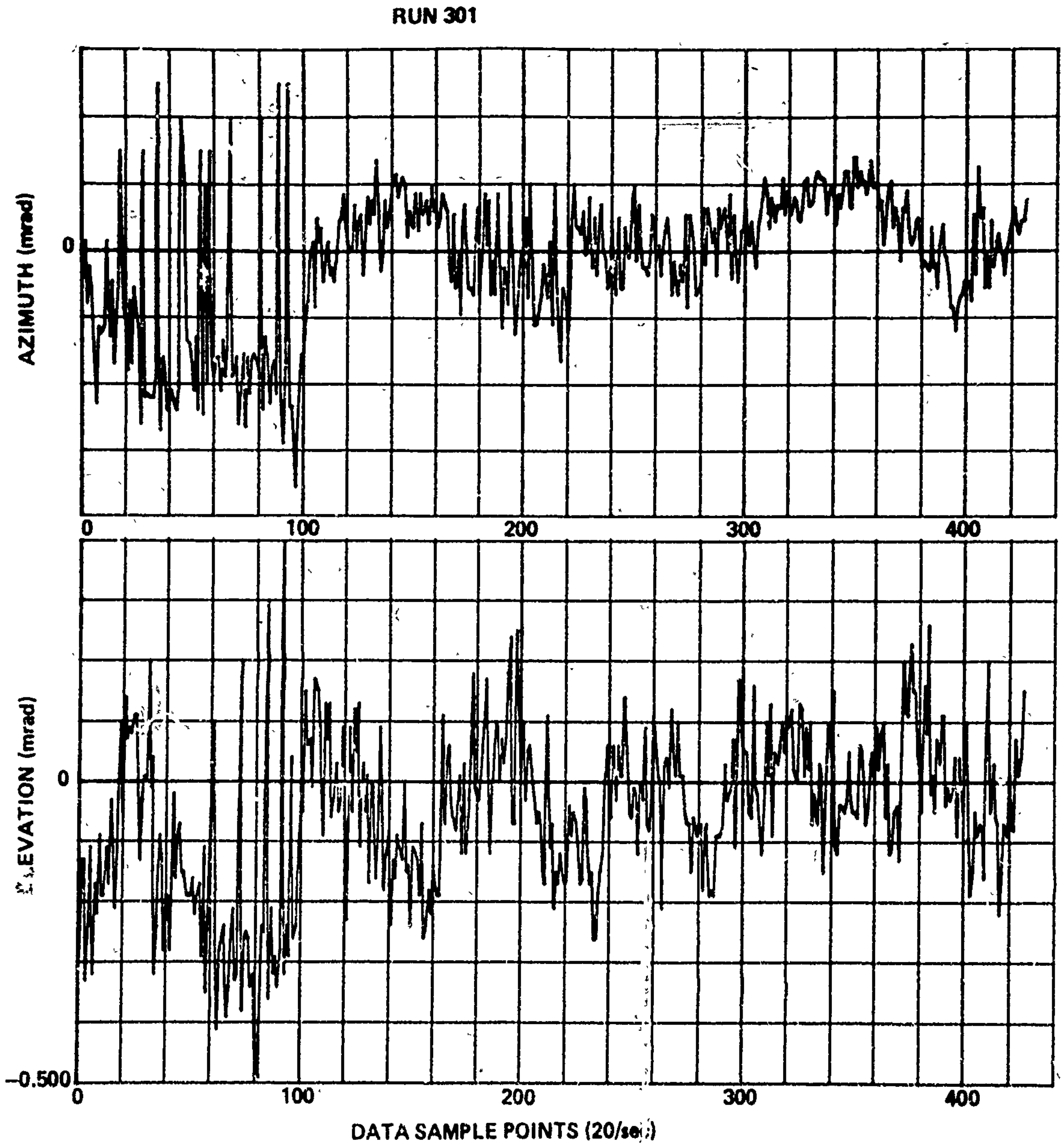


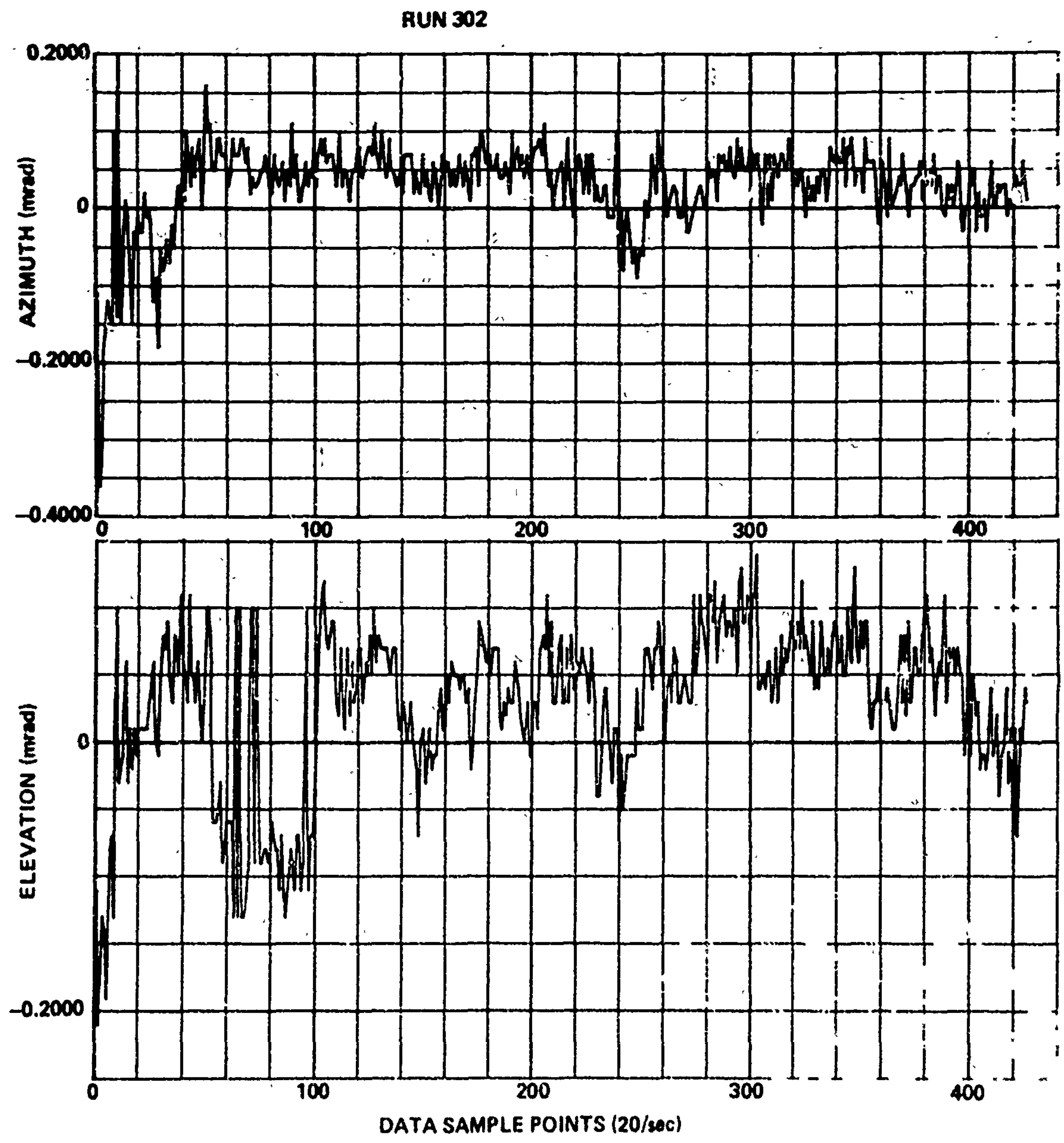
RUN 297
AZIMUTH (mrad)
0
0.500
ELEVATION (mrad)
0
−0.500
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)

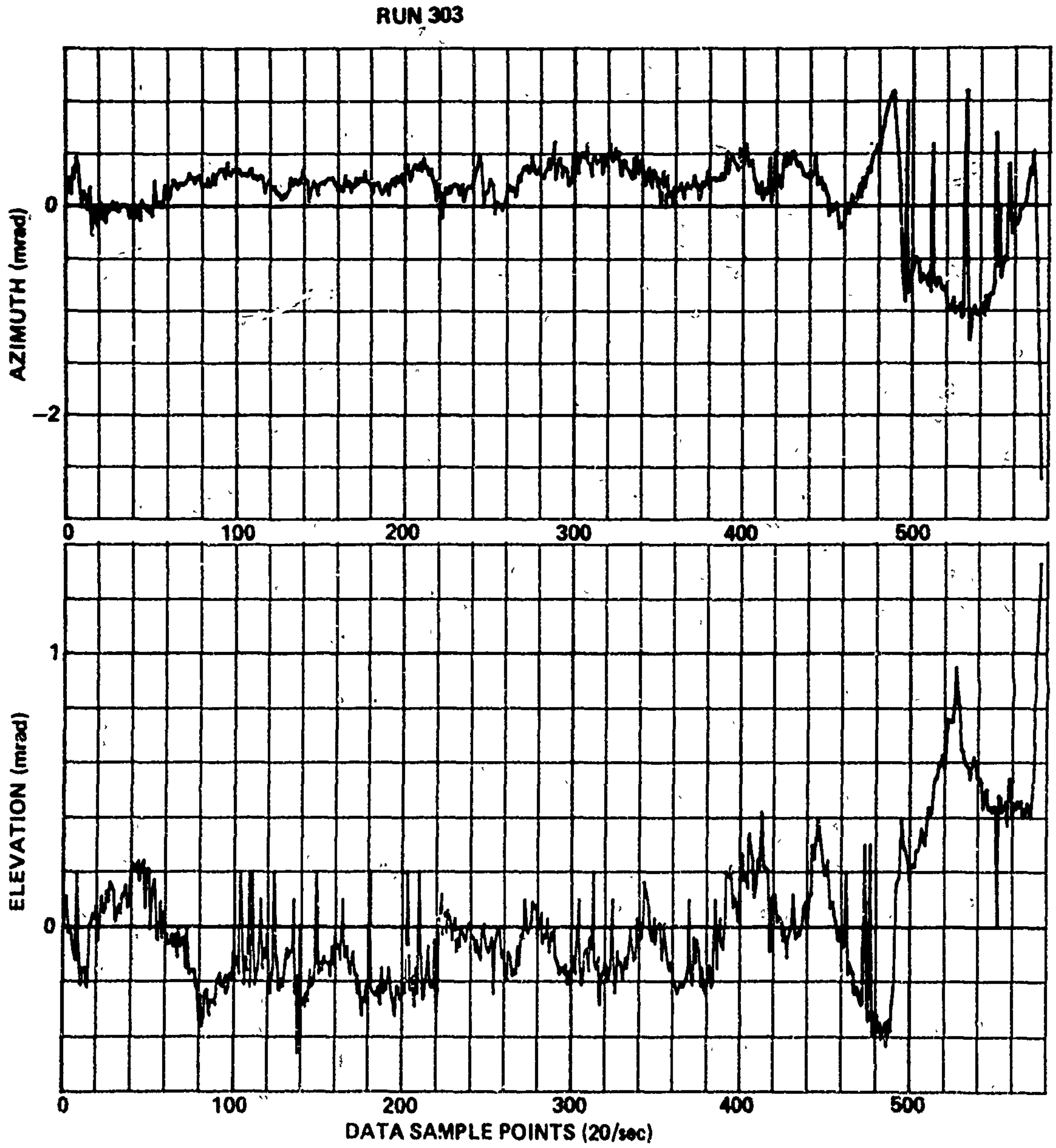


RUN 298
AZIMUTH (mrad)
1
0
0
100
200
300
400
ELEVATION (mrad)
0.20
0
-0.20
-0.40
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)


RUN 300
AZIMUTH (mrad)
0
-1
0
100
200
300
400
ELEVATION (mrad)
0.500
0
-0.500
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)

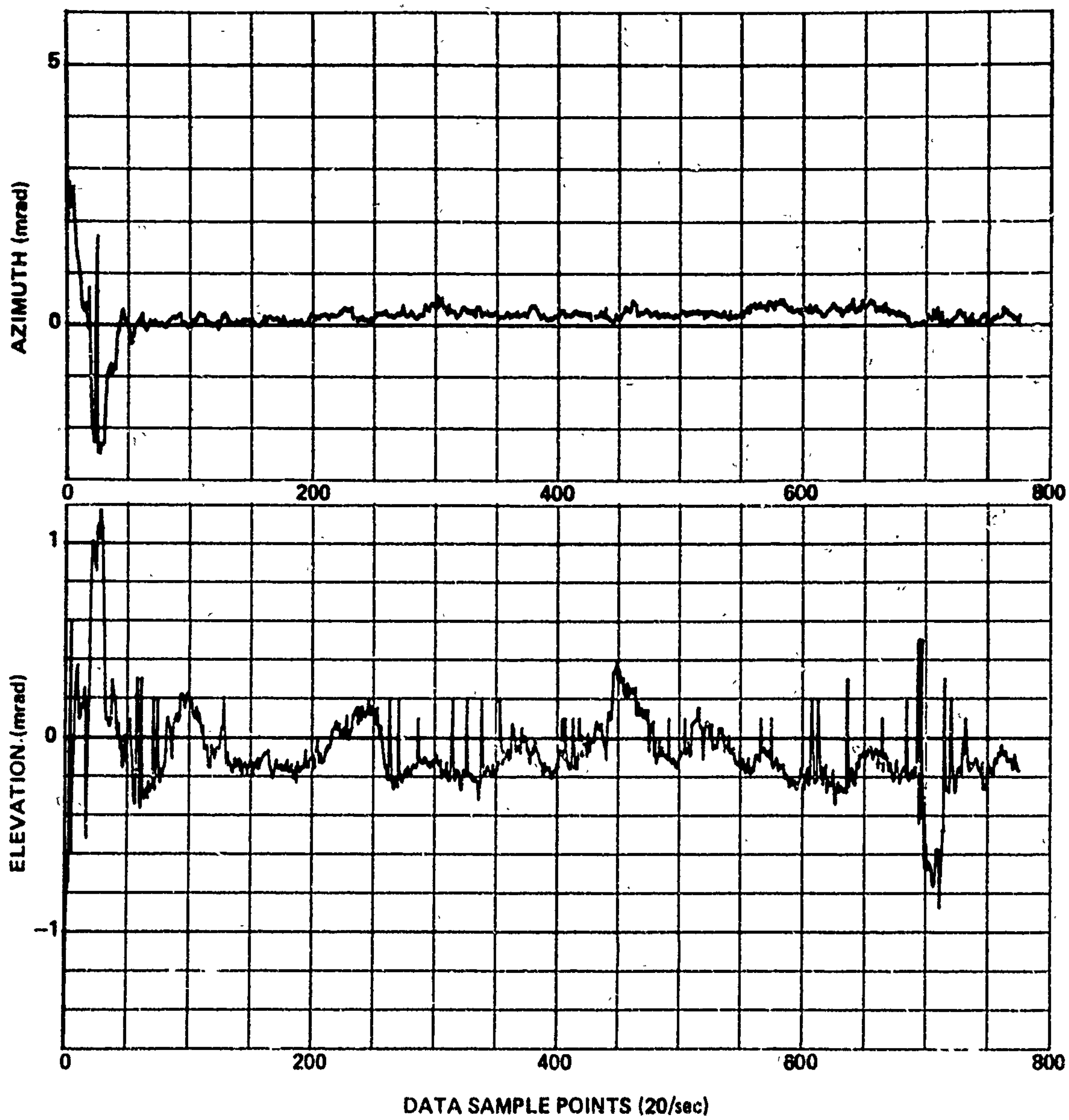

RUN 301
AZIMUTH (mrad)
0
0
100
200
300
400
ELEVATION (mrad)
0
-0.500
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)


RUN 302
AZIMUTH (mrad)
0.2000
0
-0.2000
-0.4000
ELEVATION (mrad)
0
-0.2000
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)



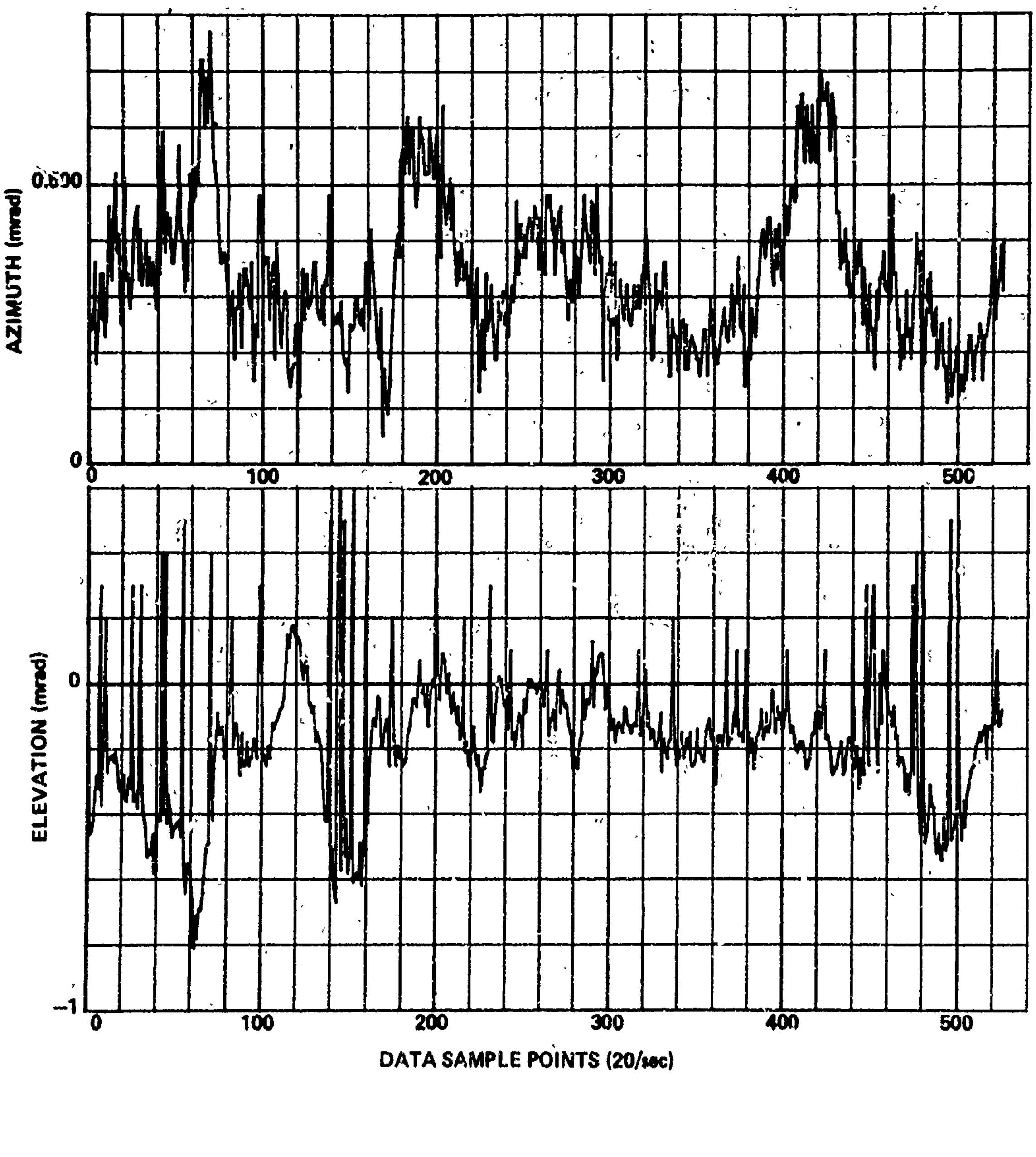
RUN 303
AZIMUTH (mrad)
0
−2
0
100
200
300
400
500
ELEVATION (mrad)
1
0
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

RUN 305



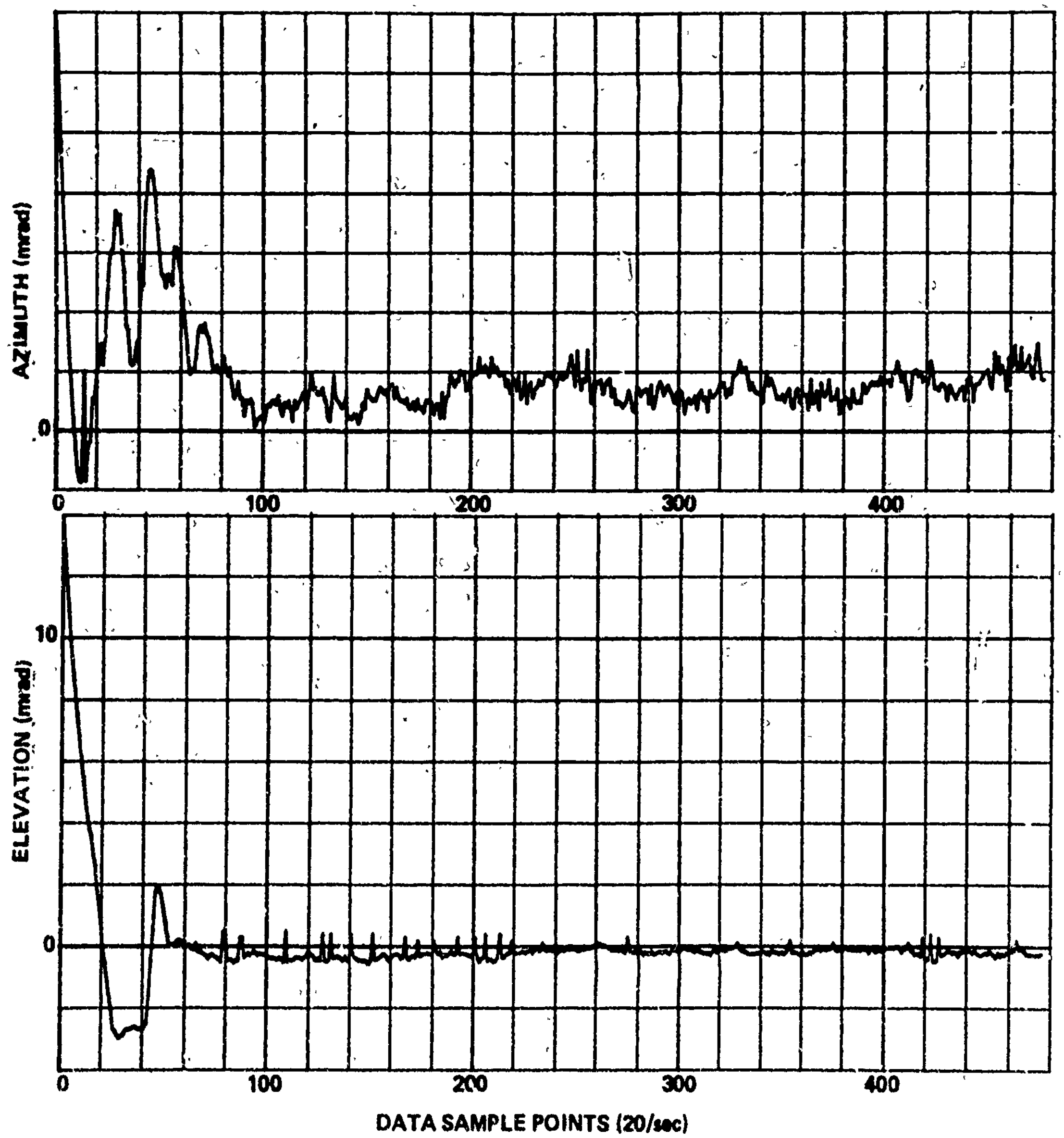
5
0
AZIMUTH (mrad)
0
200
400
600
800
1
0
-1
ELEVATION (mrad)
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)

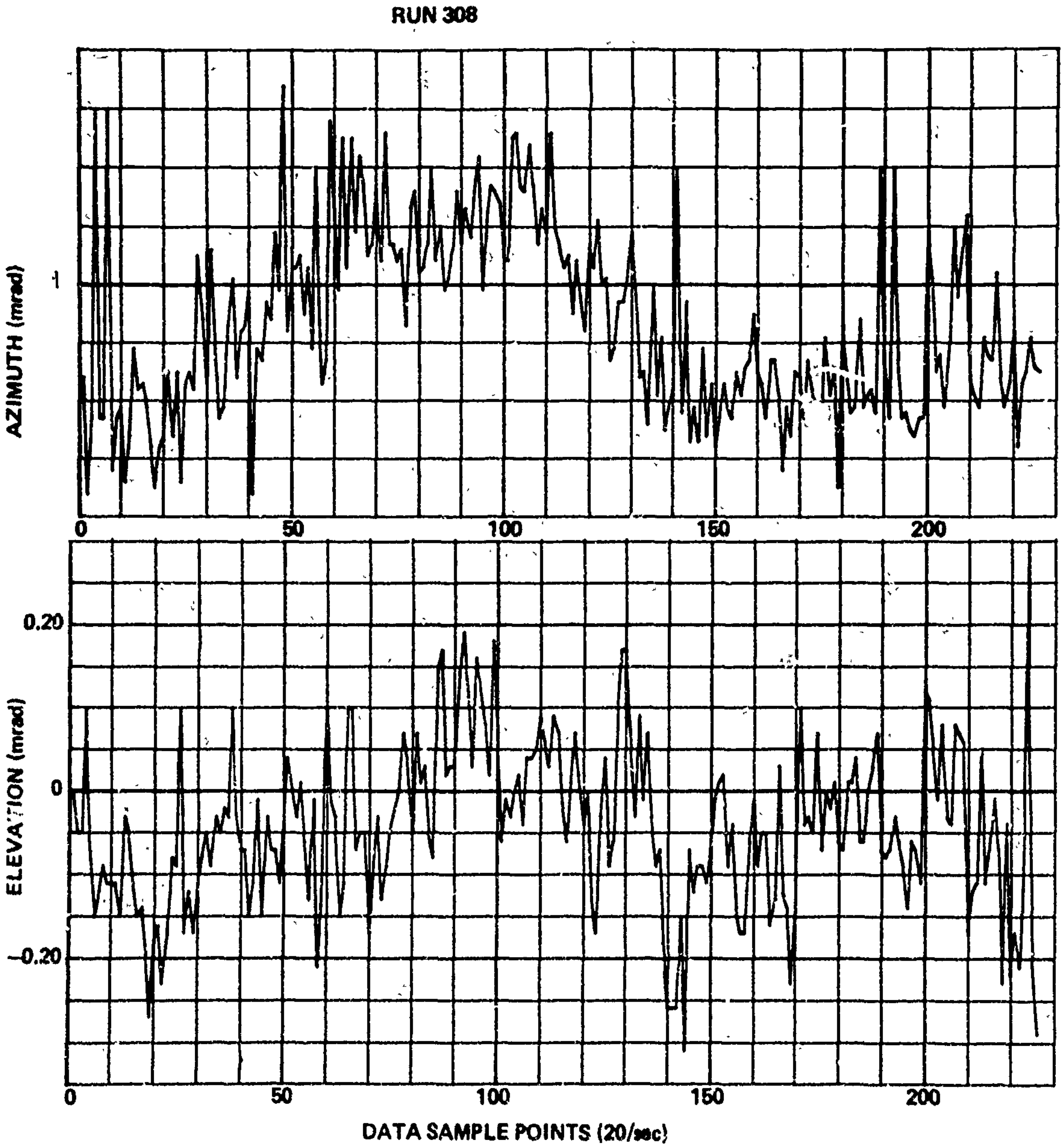
RUN 306



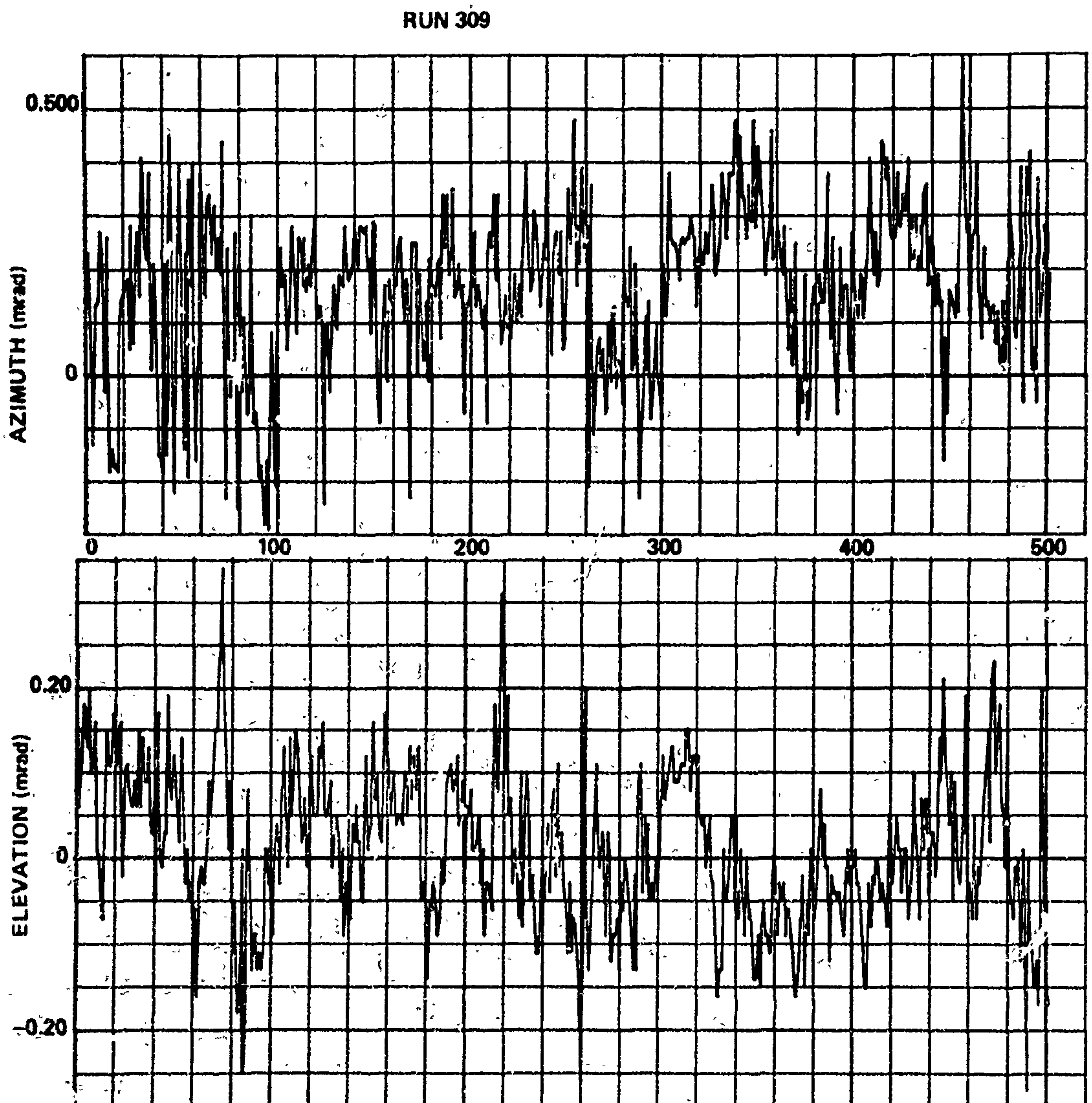
0.500
0
AZIMUTH (mrad)
0
100
200
300
400
500
0
-1
ELEVATION (mrad)
0
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

RUN 307

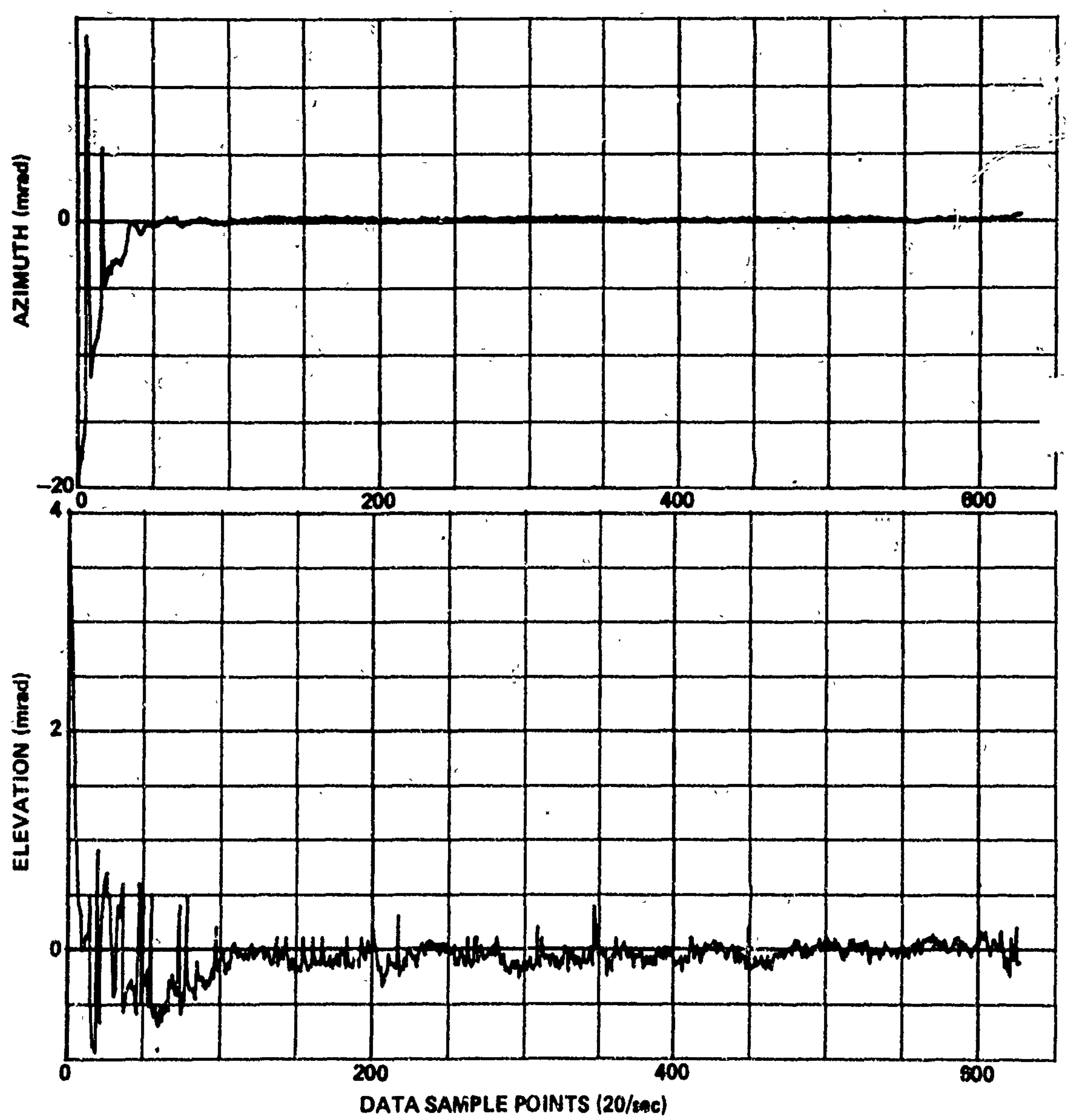

AZIMUTH (mrad)
0
0
100
200
300
400
ELEVATION (mrad)
10
0
0
100
200
300
400
DATA SAMPLE POINTS (20/sec)



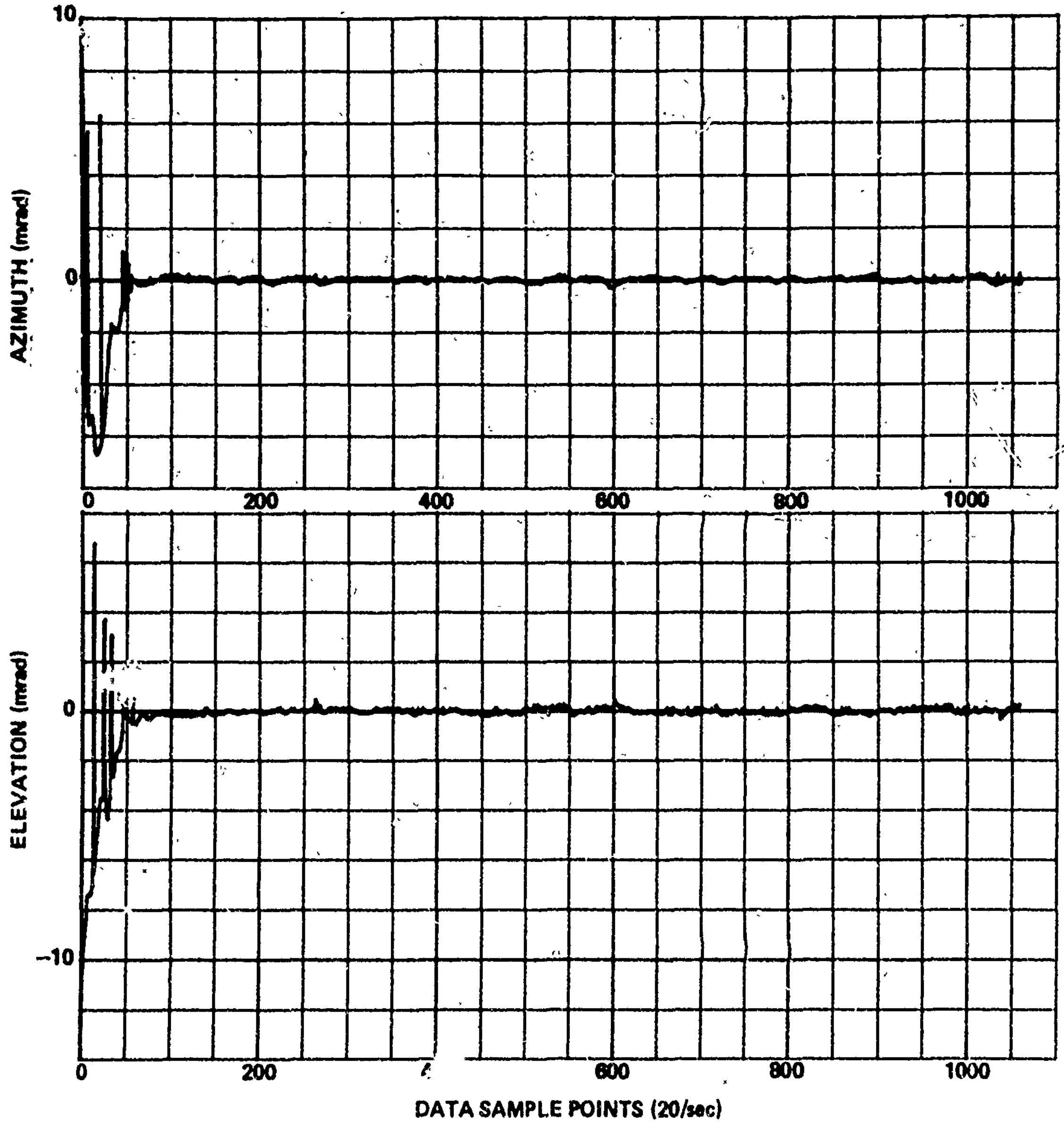
RUN 308
AZIMUTH (mrad)
1
0
50
100
150
200
ELEVATION (mrad)
0.20
0
-0.20
0
50
100
150
200
DATA SAMPLE POINTS (20/sec)


RUN 309
0.500
0
AZIMUTH (mrad)
0
100
200
300
400
500
0.20
0
-0.20
ELEVATION (mrad)
100
200
300
400
500
DATA SAMPLE POINTS (20/sec)

RUN 311

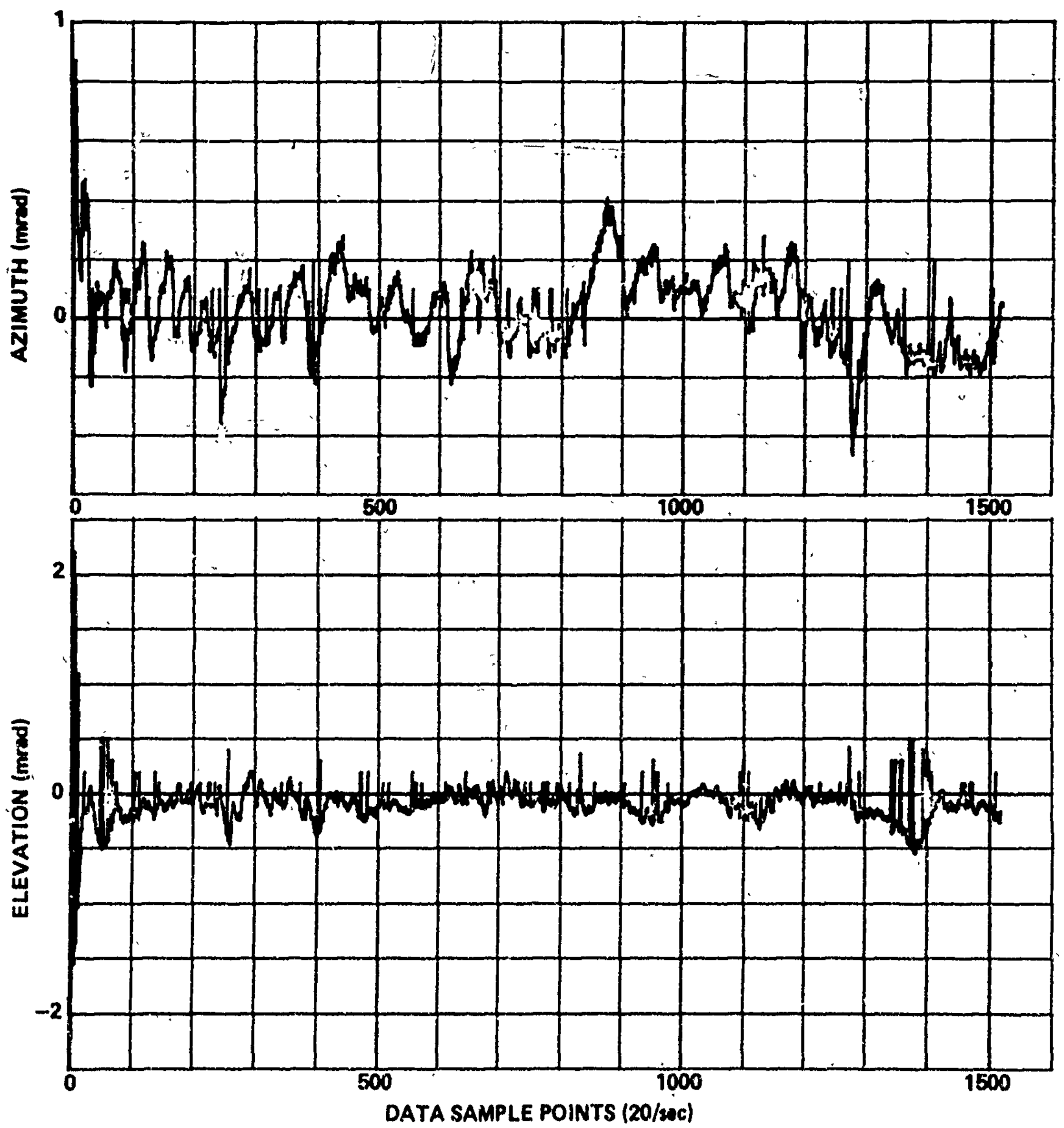

AZIMUTH (mrad)
0
-20
0
200
400
600
ELEVATION (mrad)
4
2
0
0
200
400
600
DATA SAMPLE POINTS (20/sec)

RUN 312

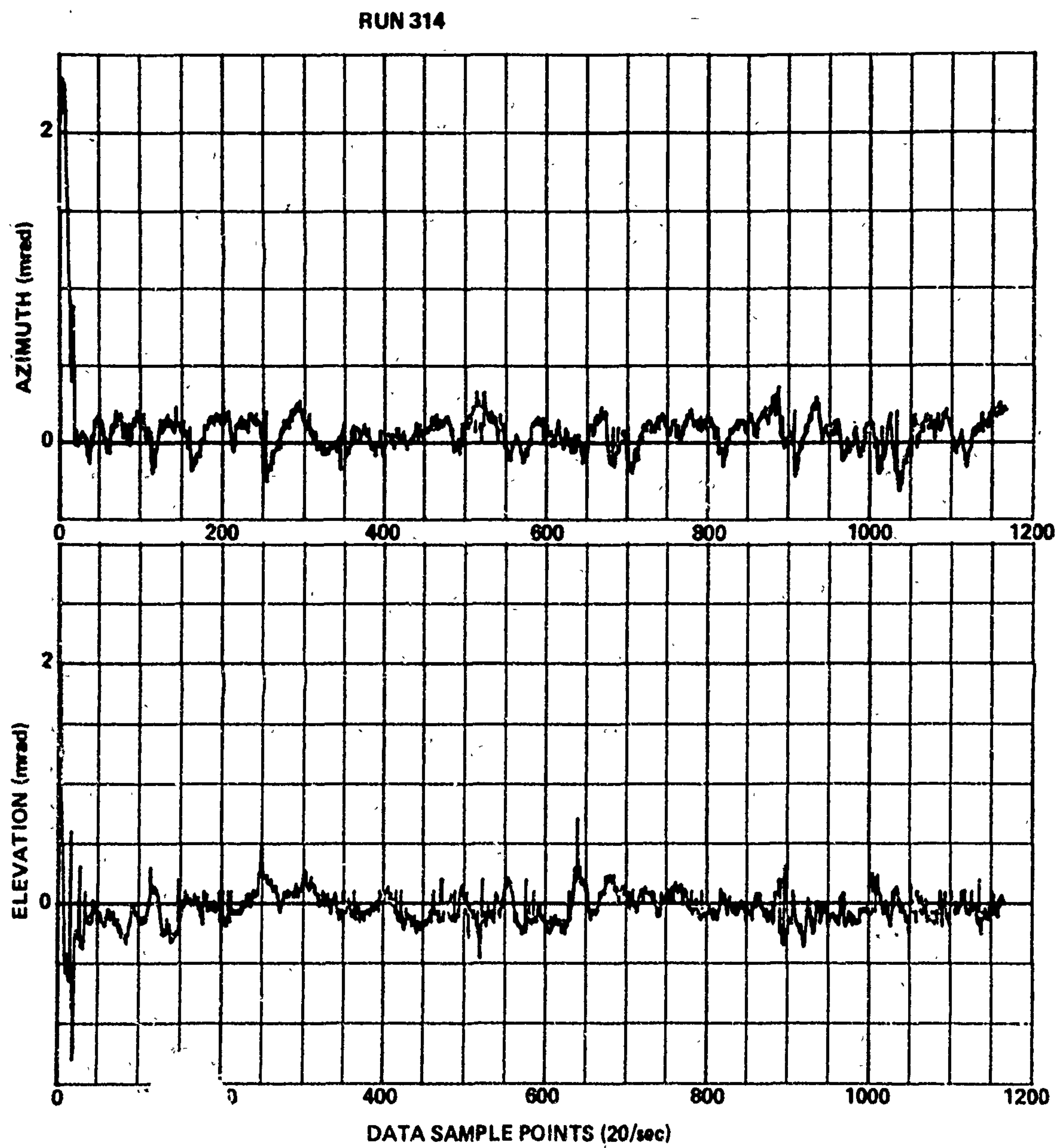


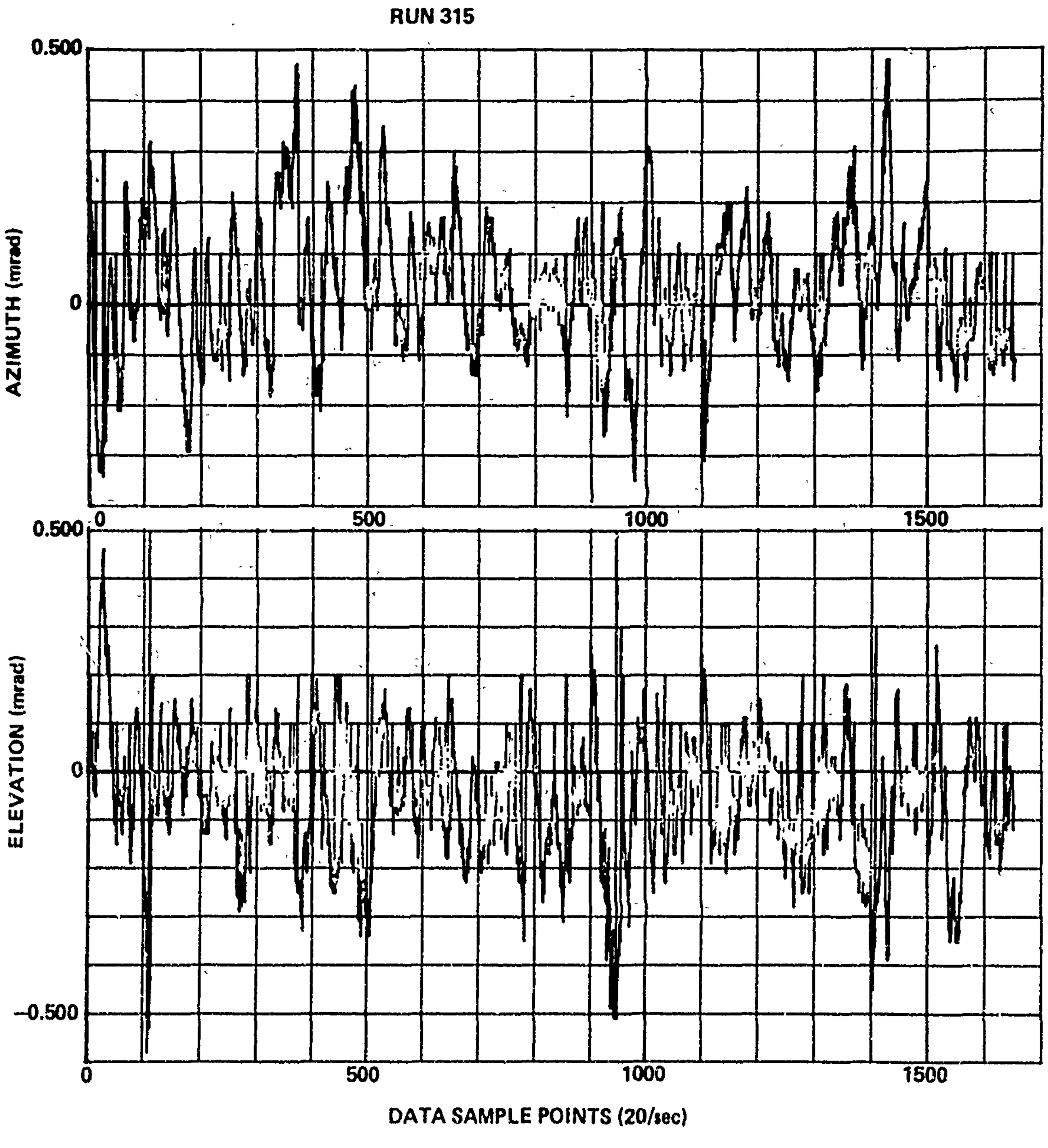
10
0
AZIMUTH (mrad)
0
200
400
600
800
1000
0
-10
ELEVATION (mrad)
0
200
600
800
1000
DATA SAMPLE POINTS (20/sec)

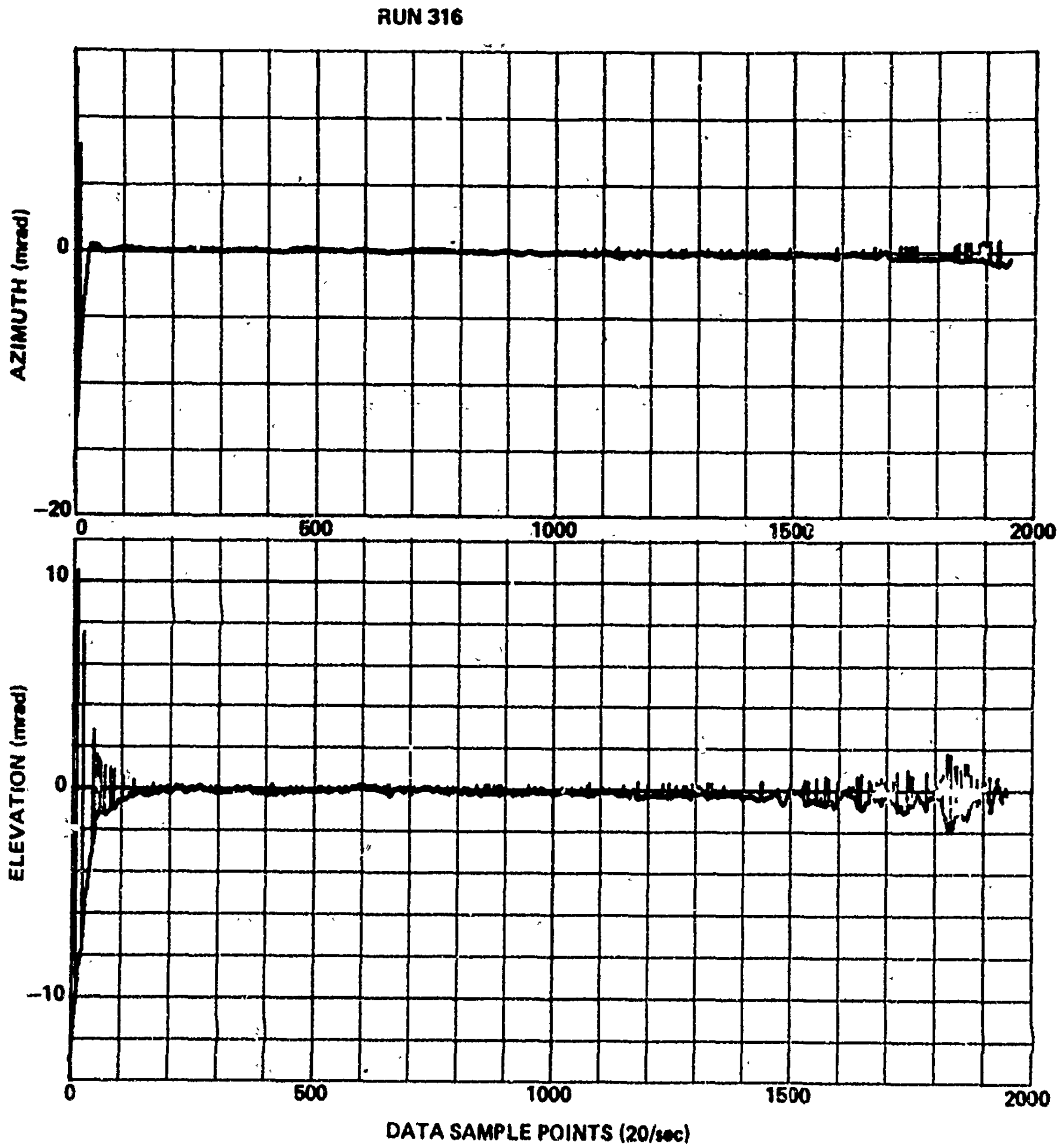
RUN 313



1
0
AZIMUTH (mrad)
0
500
1000
1500
2
0
-2
ELEVATION (mrad)
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

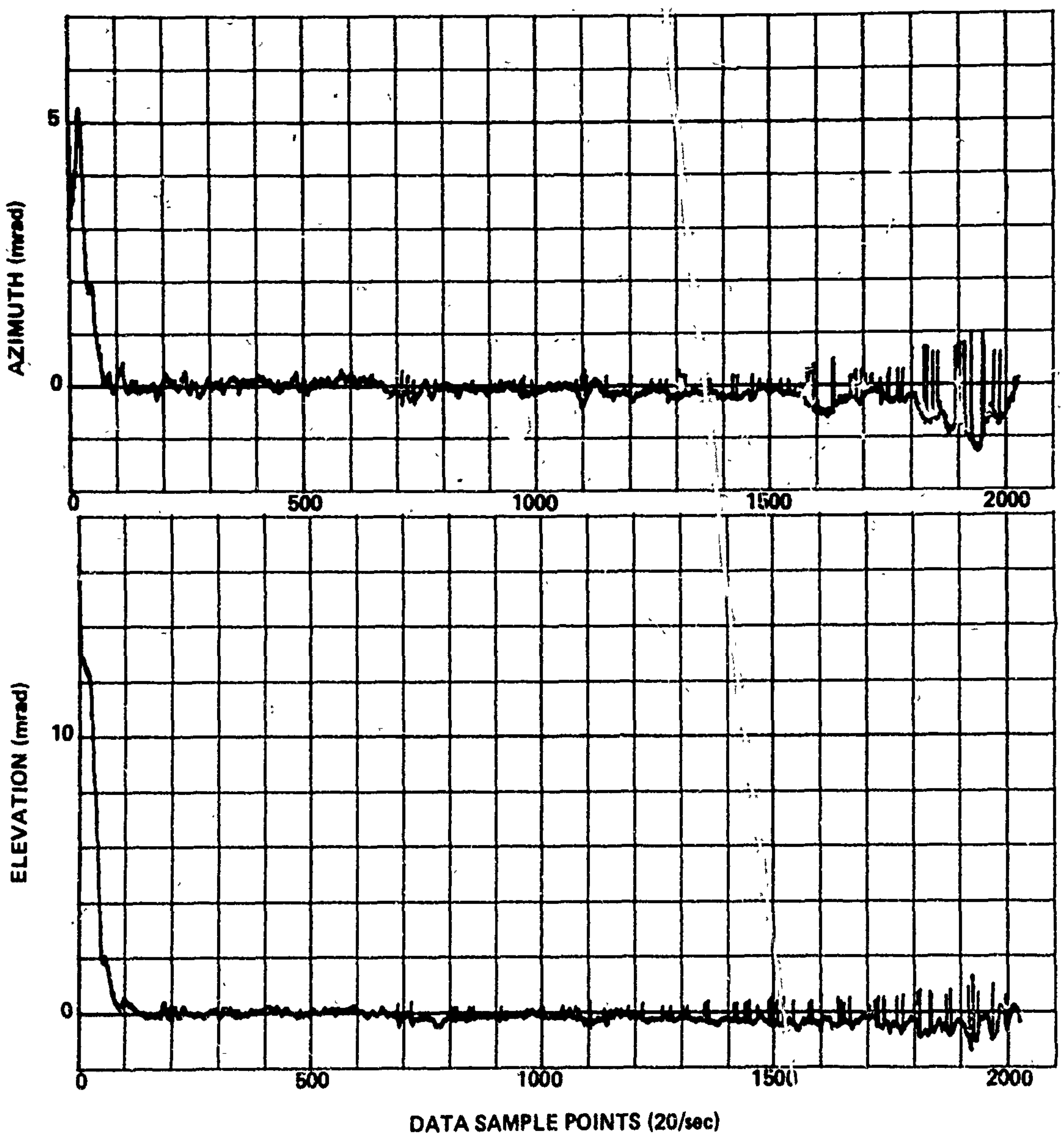

RUN 314
AZIMUTH (mrad)
ELEVATION (mrad)
2
0
200
400
600
800
1000
1200
DATA SAMPLE POINTS (20/sec)


RUN 315
0.500
0
AZIMUTH (mrad)
0
500
1000
1500
0.500
0
-0.500
ELEVATION (mrad)
0
500
1000
1500
DATA SAMPLE POINTS (20/sec)

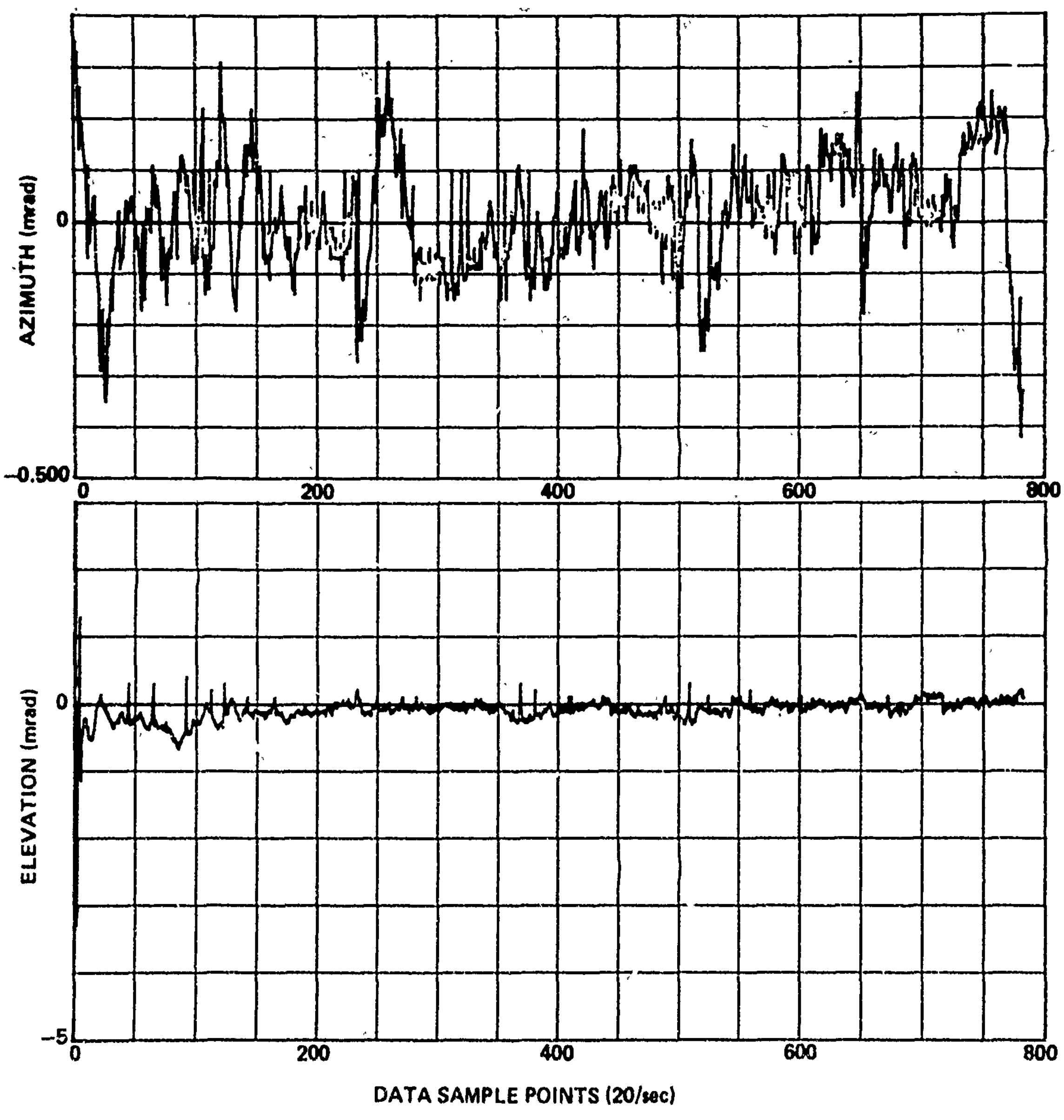


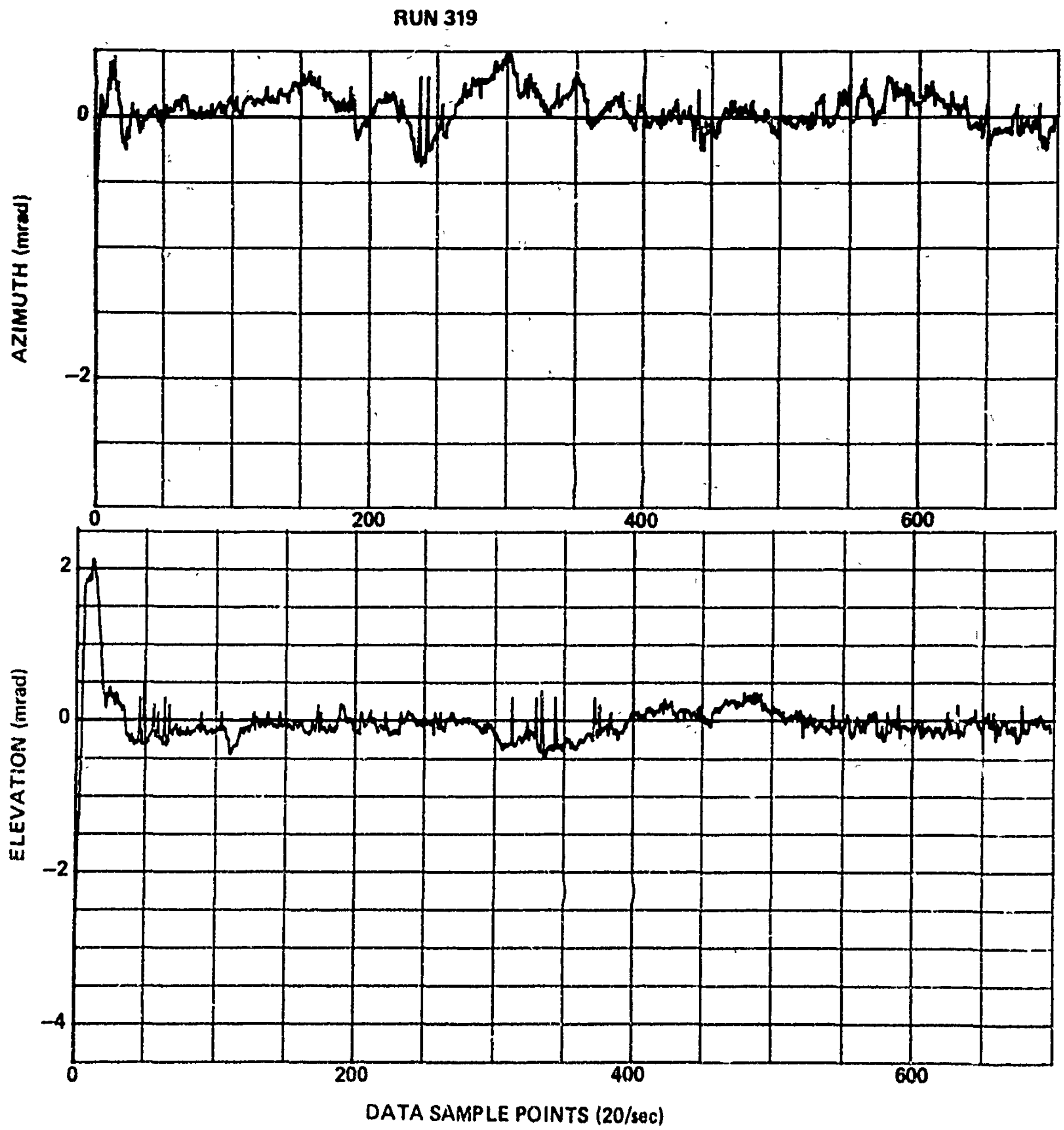
RUN 316
AZIMUTH (mrad)
0
-20
0
500
1000
1500
2000
ELEVATION (mrad)
10
0
-10
0
500
1000
1500
2000
DATA SAMPLE POINTS (20/sec)

RUN 317

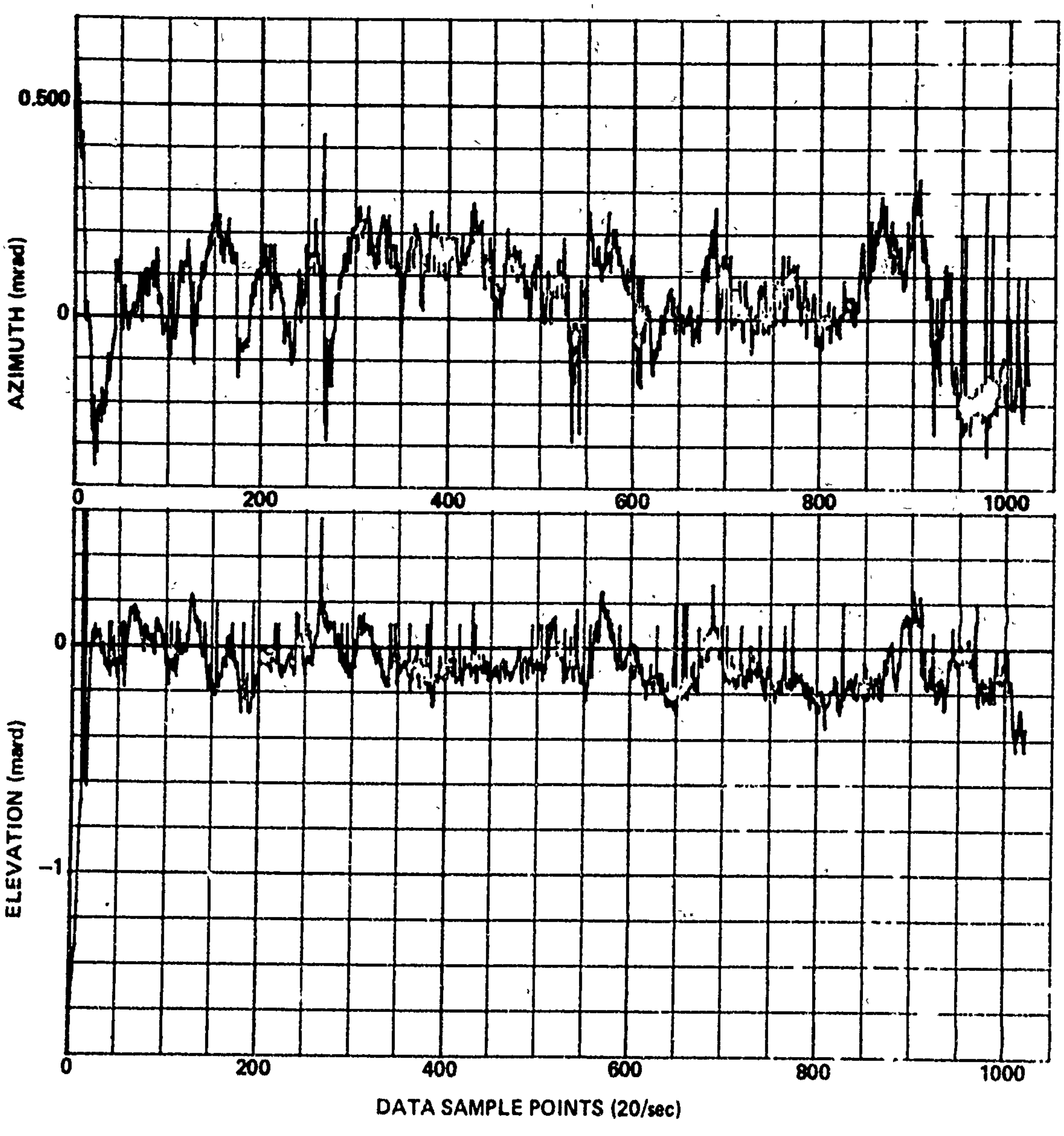

AZIMUTH (mrad)
5
0
0
500
1000
1500
2000
ELEVATION (mrad)
10
0
0
500
1000
1500
2000
DATA SAMPLE POINTS (20/sec)

RUN 318


AZIMUTH (mrad)
0
−0.500
0
200
400
600
800
ELEVATION (mrad)
0
−5
0
200
400
600
800
DATA SAMPLE POINTS (20/sec)


RUN 319
AZIMUTH (mrad)
0
−2
0
200
400
600
ELEVATION (mrad)
2
0
−2
−4
0
200
400
600
DATA SAMPLE POINTS (20/sec)

RUN 320


0.500
0
AZIMUTH (mrad)
0
200
400
600
800
1000
0
-1
ELEVATION (mard)
0
200
400
600
800
1000
DATA SAMPLE POINTS (20/sec)

REFERENCES

1. Box, G. E. P. and Jenkins, G. M., Time Series Analysis, Forecasting and Control, Holden-Day, San Francisco, 1970.

2. Fuller, F. C., Jr. and Tsokos, C. P., "Time Series Analysis of Water Pollution Data," Biometrics, 1971, pp. 1017-1034.

3. Cleveland, W. S., "Fitting Time Series Models for Prediction," Technometrics, 1971, pp. 713-723.

4. Cleveland, W. S., "The Inverse Autocorrelations of a Time Series and Their Applications," (with discussion by Parzen), Technometrics, 1972, pp. 277-298.

5. Box, G. E. P., Jenkins, G. M., and Bacon, D. W., "Models for Forecasting, Seasonal and Nonseasonal Time Series," Spectral Analysis of Time Series, ed by B. Harris, Wiley, N. Y., 1967.

6. Clevenson, M. L., "Asymptotically Efficient Estimates of the Parameters of a Moving Average Time Series," Stanford University Tech. Rep. #15, 1970.

7. Parzen E., "Efficient Estimation of Stationary Time Series Mixed Schemes," SUNY/Buffalo Tech. Rep., 1972.

Appendix A.

SIMULATION PROGRAM LISTING

```
      PROGRAM MAIN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      DIMENSION ALIMIT(10),ELIMIT(10),XUA(11),XUE(11),XLA(11),XLE(11),
     A PM(11),PME(11),SP(11),SPE(11),A(500),AE(500),AZ(500),EL(500)
      DIMENSION SP1(11),SPE1(11),PHI(11),PHE(11)
      DIMENSION B(11),RR(11),RI(11),R(11)
      DIMENSION IK(500)
      DATA B/11*0.0/
      DATA ALIMIT/0.,.3291,.8063,.8549,.9114,.9436,.9517,.9759,.9920,1./
      DATA ELIMIT/0.,.6649,.7501,.8460,.9193,.3677,.9750,.9839,.9920,1./
      READ 101,(PM(I),I=1,11)
      READ 101,(SP(I),I=1,11)
      READ 101,(PME(I),I=1,11)
      READ 101,(SPE(I),I=1,11)
      READ 101,AMEAN,AMV,EMEAN,EMV,VARA,VVARA,VARE,VVARE
      NPTS = 300
      JUMPA = 0
      JUMPE = 0
C      DETERMINE ORDER OF TIME SERIES
      START = 0.
      STERT = 0.
      CALL RANNUM(1.,START,RNA)
      CALL RANNUM(1.,STERT,RNE)
      DO 10 I = 2,9
      IF((RNA.GE.ALIMIT(I)).AND.(RNA.LT.ALIMIT(I+1))) JUMPA=I+2
      IF((RNE.GE.ELIMIT(I)).AND.(RNE.LT.ELIMIT(I+1))) JUMPE=I+2
   10 CONTINUE
C      GENERATE MU,PHI-S,VAR(A)
      DO 302 I = 1,11
      SP1(I) = SQRT(SP(I))
  302 SPE1(I) = SQRT(SPE(I))
      DO 20 I = 1,11
      XUA(I) = PM(I) + 5.*SP1(I)
      XLA(I) = PM(I) - 5.*SP1(I)
      XUE(I) = PME(I) + 5.*SPE1(I)
   20 XLE(I) = PME(I) - 5.*SPE1(I)
   62 DO 54 I = 1,11
   54 PHI(I) = 0.0
      DO 40 I = 1,3
   40 CALL NORMAL(PHI(I),XLA(I),XUA(I),PM(I),SP1(I))
      IF(JUMPA.EQ.0) GO TO 50
      I = JUMPA
      CALL NORMAL(PHI(I),XLA(I),XUA(I),PM(I),SP1(I))
      NN = JUMPA
      GO TO 55
   50 NN = 3
   55 R(1) = 1.0
      DO 57 I = 1,NN
   57 R(I+1) = -PHI(I)
      CALL ROOTS(R,B,NN,RR,RI)
      INOSA = 0
      DO 56 I = 1,NN
      IF(ABS(RR(I)).GE.1.) INOSA=1
   56 CONTINUE
      IF(INOSA.NE.1) GO TO 61
      PRINT 102
      GO TO 62
   61 DO 63 I = 1,11
```

```
   63 PHE(I) = 0.
      DO 65 I = 1,3
   65 CALL NORMAL(PHE(I),XLE(I),XUE(I),PHE(I),SPE1(I))
      IF(JUMPE.EQ.0) GO TO 66
      I = JUMPE
      CALL NORMAL(PHE(I),XLE(I),XUE(I),PHE(I),SPE1(I))
      NN = JUMPE
      GO TO 67
   66 NN = 3
   67 R(1) = 1.0
      DO 62 I = 1,NN
   62 R(I+1) = -PHE(I)
      CALL ROOTS(R,B,NN,RR,RI)
      INDSE = 0
      DO 68 I = 1,NN
      IF(ABS(RR(I)).GE.1.) INDSE=1
   68 CONTINUE
      IF(INDSE.NE.1) GO TO 69
      PRINT 103
      GO TO 61
   69 AMV1 = SQRT(AMV)
      EMV1 = SQRT(EMV)
      VVARA1 = SQRT(VVARA)
      VVARE1 = SQRT(VVARE)
      XLMA = AMEAN-3.*AMV1
      XLME = EMEAN-3.*EMV1
      XUMA = AMEAN+3.*AMV1
      XUME = EMEAN+3.*EMV1
      CALL NORMAL(AMN,XLMA,XUMA,AMEAN,AMV1)
      CALL NORMAL(EMN,XLME,XUME,EMEAN,EMV1)
      XLVA = VARA - 5.*VVARA1
      XLVE = VARE - 5.*VVARE1
      XUVA = VARA + 5.*VVARA1
      XUVE = VARE + 5.*VVARE1
      CALL NORMAL(AVAR,XLVA,XUVA,VARA,VVARA1)
      CALL NORMAL(EVAR,XLVE,XUVE,VARE,VVARE1)
C     GENERATE A(T)-S
      AVAR1 = SQRT(AVAR)
      EVAR1 = SQRT(EVAR)
      XLAA = -5.*AVAR1
      XLAE = -5.*EVAR1
      XUAA = 5.*AVAR1
      XUAE = 5.*EVAR1
      DO 80 I = 1,NPTS
      CALL NORMAL(A(I),XLAA,XUAA,0.,AVAR1)
   80 CALL NORMAL(AE(I),XLAE,XUAE,0.,EVAR1)
C     PRINT INITIALLY SELECTED VALUES
      PRINT 1
      IF(JUMPA.EQ.0) GO TO 90
      PRINT 2,AMN,AVAR,(PHI(I),I=1,3),JUMPA,PHI(JUMPA)
      GO TO 100
   90 PRINT 3,AMN,AVAR,(PHI(I),I=1,3)
  100 IF(JUMPE.EQ.0) GO TO 110
      PRINT 4,EMN,EVAR,(PHE(I),I=1,3),JUMPE,PHI(JUMPE)
      GO TO 120
  110 PRINT 5,EMN,EVAR,(PHE(I),I=1,3)
    5 FORMAT(3X*ELEVATION*F6.4,4F6.4)
```

```
  120 PRINT 6
C       COMPUTE AZ AND EL VALUES
      AZ(1) = AMN + A(1)
      AZ(2) = AMN+PHI(1)*(AZ(1)-AMN) +A(2)
      AZ(3) = AMN+PHI(1)*(AZ(2)-AMN)+PHI(2)*(AZ(1)-AMN) +A(3)
      IF(JUMPA.EQ.0) GO TO 300
      DO 310 I = 4,JUMPA
  310 AZ(I) = AMN+PHI(1)*(AZ(I-1)-AMN)+PHI(2)*(AZ(I-2)-AMN)+PHI(3)*
     A (AZ(I-3)-AMN) +A(I)
      J = JUMPA + 1
      DO 330 I = J,NPTS
  330 AZ(I) = AMN+PHI(1)*(AZ(I-1)-AMN)+PHI(2)*(AZ(I-2)-AMN)+PHI(3)*
     A (AZ(I-3)-AMN)+PHI(JUMPA)*(AZ(I-JUMPA)-AMN) +A(I)
      GO TO 340
  300 DO 320 I = 4,NPTS
  320 AZ(I) = AMN+PHI(1)*(AZ(I-1)-AMN)+PHI(2)*(AZ(I-2)-AMN)+PHI(3)*
     A (AZ(I-3)-AMN) +A(I)
C
  340 EL(1) = EMN+AE(1)
      EL(2) = EMN+PHE(1)*(EL(1)-EMN) +AE(2)
      EL(3) = EMN+PHE(1)*(EL(2)-EMN)+PHE(2)*(EL(1)-EMN)+AE(3)
      IF(JUMPE.EQ.0) GO TO 460
      DO 410 I = 4,JUMPE
  410 EL(I) = EMN+PHE(1)*(EL(I-1)-EMN)+PHE(2)*(EL(I-2)-EMN)+PHE(3)*
     A (EL(I-3)-EMN) +AE(I)
      J = JUMPE + 1
      DO 440 I = J,NPTS
  440 EL(I) = EMN+PHE(1)*(EL(I-1)-EMN)+PHE(2)*(EL(I-2)-EMN)+PHE(3)*
     A (EL(I-3)-EMN)+PHE(JUMPE)*(EL(I-JUMPE)-EMN)+AE(I)
      GO TO 450
  460 DO 420 I = 4,NPTS
  420 EL(I) = EMN+PHE(1)*(EL(I-1)-EMN)+PHE(2)*(EL(I-2)-EMN)+PHE(3)*
     A (EL(I-3)-EMN) +AE(I)
C       PRINT VALUES
  450 DO 430 I = 1,NPTS
  430 IK(I) = I
      IB = 0
      IE = 0
      IF(NPTS.LT.220) GO TO 451
      IB = IE + 1
      IE = IB + 54
  454 DO 452 I = IB,IE
  452 PRINT 8,IK(I),AZ(I),EL(I),IK(I+55),AZ(I+55),EL(I+55),IK(I+110),
     1  AZ(I+110),EL(I+110),IK(I+165),AZ(I+165),EL(I+165)
      PRINT 104
      PRINT 6
      IF((NPTS-4*IE).LT.220) GO TO 451
      IB = 4*IE + 1
      IE = IB + 54
      GO TO 454
  451 NLEFT=NPTS-4*IE
      NCOL=NLEFT/55
      NEX = NLEFT-NCOL*55
      IB = 4*IE + 1
      IE = IB + 54
      GO TO (455,456,457),NCOL
  455 IF(NEX.EQ.0) GO TO 461
```

```
      NEX = IB + NEX - 1
      DO 458 I = IB,NEX
  458 PRINT 8,IK(I),AZ(I),EL(I),IK(I+55),AZ(I+55),EL(I+55)
      NX1 = NEX + 1
      DO 459 I = NX1,IE
  459 PRINT 3,IK(I),AZ(I),EL(I)
      GO TO 10000
  461 DO 462 I = IB,IE
  462 PRINT 8,IK(I),AZ(I),EL(I)
      GO TO 10000
  455 IF(NEX.EQ.0) GO TO 463
      NEX = IB + NEX - 1
      DO 464 I = IB,NEX
  464 PRINT 8,IK(I),AZ(I),EL(I),IK(I+55),AZ(I+55),EL(I+55),IK(I+110),
     1  AZ(I+110),EL(I+110)
      NX1 = NEX + 1
      DO 465 I = NX1,IE
  465 PRINT 8,IK(I),AZ(I),EL(I),IK(I+55),AZ(I+55),EL(I+55)
      GO TO 10000
  463 DO 466 I = IB,IE
  466 PRINT 8,IK(I),AZ(I),EL(I),IK(I+55),AZ(I+55),EL(I+55)
      GO TO 10000
  457 IF(NEX.EQ.0) GO TO 473
      NEX = IB + NEX - 1
      DO 474 I = IB,NEX
  474 PRINT 8,IK(I),AZ(I),EL(I),IK(I+55),AZ(I+55),EL(I+55),IK(I+110),
     1 AZ(I+110),EL(I+110),IK(I+165),AZ(I+165),EL(I+165)
      NX1 = NEX + 1
      DO 475 I = NX1,IE
  475 PRINT 8,IK(I),AZ(I),EL(I),IK(I+55),AZ(I+55),EL(I+55),IK(I+110),
     1  AZ(I+110),EL(I+110)
      GO TO 10000
  473 DO 476 I = IB,IE
  476 PRINT 8,IK(I),AZ(I),EL(I),IK(I+55),AZ(I+55),EL(I+55),IK(I+110),
     1  AZ(I+110),EL(I+110)
    1 FORMAT(1H1,25X*INITIALLY SELECTED VALUES*/13X*MEAN*2X*AVAR*2X
     A*PHI1*2X*PHI2*2X*PHI3*2X*JUMP*2X*PHI(JUMP)*)
    2 FORMAT(3X*AZIMUTH  *F6.4,4F6.4,3XI2,4XF6.4)
    3 FORMAT(3X*AZIMUTH  *F6.4,F5.4)
    4 FORMAT(3X*ELEVATION*F6.4,4F5.4,3XI2,4XF6.4)
    5 FORMAT(//,3X*TIME*3X*AZIMUTH*3X*ELEVATION*,3(4X*TIME*3X*AZIMUTH*3X
     1 *ELEVATION*))
    7 FORMAT(3XI3,5XF6.4,5XF6.4)
    8 FORMAT(4XI3,1XF8.4,5XF8.4,3(5XI3,1XF8.4,5XF8.4))
  101 FORMAT(5X11F6.4)
  102 FORMAT(///,10X*INOSA = 1, REITERATED*)
  103 FORMAT(///,10X*INOSE=1, REITERATED*)
  104 FORMAT(1H1)
10000 STOP
      END
```

```
      SUBROUTINE NORMAL( RX,XL,XU,MU,SIGMA)
C     SUBROUTINE NORMAL( RX, XL, XU, MU, SIGMA )
C     DESCRIPTION
C         THIS ROUTINE PRODUCES NORMALIZED RANDOM NUMBERS WITHIN
C         A RANGE SPECIFIED BY THE USER.
C     INPUT
C          1  XL       LOWER LIMIT OF NORMAL CURVE
C          2  XU       UPPER LIMIT OF NORMAL CURVE
C          3  MU       MEAN OF NORMAL CURVE (TYPE REAL)
C          4  SIG      STANDARD DEVIATION OF NORMAL CURVE
C     OUTPUT
C          1  RX       THE NORMALIZED RANDOM NUMBER
C
      DIMENSION FZ(126)
      REAL MU
      DATA DT,DT1,NTP,NPT,SQ2PI/.01,.04,126,0,.398942283/
      SL5 = MU - 5.0 * SIGMA
      SU5 = MU + 5.0 * SIGMA
      IF( XL .LE. SU5 .AND. XU .GE. SL5 ) GO TO 10
      PRINT 101, SL5, SU5, XL, XU, MU, SIGMA
  101 FORMAT(*1LIMITS FOR NORMAL DISTRIBUTION SHOULD BE BETWEEN*F10.2
     1        * AND*F10.2 * --- PROGRAM TERMINATED.*///* XL =*F10.2,5X
     2        * XU =* F10.2,5X* MU =*F10.2,5X* SIGMA =*F10.2)
      STOP 123
   10 IF(NPT.NE.0) GO TO 2
      T2=DT1
      FZ(1)=.5
      FC=FZ(1)
      T=0.
      FP=SQ2PI*EXP(-.5*T*T)
      DT2=DT*.5
      NPT=1
    1 CONTINUE
      T = T+DT
      F = SQ2PI*EXP(-.5*T*T)
      FC=FC + DT2*(F+FP)
      FP=F
      IF(ABS(T-T2).GT..0001) GO TO 1
      NPT=NPT + 1
      FZ(NPT)=FC
      T2=T2+DT1
      IF(NPT.LT.NTP) GO TO 1
C
    2 CONTINUE
      RN = RANF(R)
      R=RN
      IF(RN.LT..5) R=1.-RN
      IF(R.GT.FZ(NPT)) GO TO 2
      DO 3 I=1,NPT
      IF(R.GT.FZ(I)) GO TO 3
      IF(I.EQ.1) GO TO 4
      X=I-1
      X=X*DT1
      X1=X-DT1
      RX = X1 +(R-FZ(I-1))*DT1/(FZ(I)-FZ(I-1))
      GO TO 5
    3 CONTINUE
```



```
      PRINT 100
  100 FORMAT(13H ERROR DISRN)
      STOP
    4 CONTINUE
      RX=0.
    5 CONTINUE
      IF(RN.LT..5) RX=-RX
      RX= SIGMA*RX+MU
      IF(RX.GT.XU) GO TO 2
      IF(RX.LT.XL) GO TO 2
      RETURN
      END
```